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ATTACHMENT AICAO ENVIRONMENTAL TECHNICAL MANUAL ON THE USE OF
PROCEDURES IN THE NOISE CERTIFICATION OF AIRCRAFT

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NOMENCLATURE

Symbols and abbreviations employed in this manual are consistent with those contained in ICAO Annex 16, Volume 1. First Edition - 1981.

Symbols

Symbol	Unit	
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CI	dB	90% Confidence interval in decibel units relevant to the calculation being made.
D	m	Jet nozzle diameter based on total nozzle exit area
EPNL	EPNdB	Effective Perceived Noise Level
F	N	Engine net thrust
f	Hz	1/3-octave centre frequency
K		constant
L	dB	'A' - weighted sound pressure level
M		Mach number
M _T		Propeller helical tip Mach number
N	RPM	Propeller rotational speed
N ₁	RPM	Low pressure rotor speed of turbine engines
PNL	PNdB	Perceived Noise Level
PNLT	TPNdB	Tone Corrected Perceived Noise Level
PNLTM	TPNdB	Maximum Tone Corrected Perceived Noise Level
S		Strouhal number fD/V_j
SHP	kW	Shaft horse power
SPL	dB	Sound pressure level based on a reference of $20 \mu\text{Pa}$
TCL	°C	Air temperature at engine centreline height
TMIC	°C	Air temperature at the ground plane microphone height
V _j	m/sec	Jet velocity for complete isentropic expansion to ambient pressure
V	m/sec	Aircraft airspeed
WCL	Km/h	Average wind speed at engine centreline height
x	m	Distance downstream from nozzle exit
δ_{amb}		ratio of absolute static pressure of the ambient air at the height of the aeroplane to ISA air pressure at mean sea level (ie 101.325 kPa)
θ_{t2}		ratio of absolute static temperature of the air at the height of the aeroplane to the absolute temperature of the air at sea level for ISA conditions (ie 288.15 K)
μ		engine power related parameter, or mean value see Appendix 1
λ	degrees	Angle between the flight path in the direction of flight and a straight line connecting the aeroplane and the microphone at the time of sound emission

Suffices

flt	quantity related to flight conditions
max	maximum value
ref	quantity related to reference conditions
static	quantity related to static conditions
test	quantity related to test conditions
DOP	Doppler related quantity

Abbreviations

ESDU	Engineering Sciences Data Unit
ISA	International Standard Atmosphere
NPD	Noise-power-distance
SAE AIR	Society of Automotive Engineers - Aerospace Information Report
SAE ARP	Society of Automotive Engineers - Aerospace Recommended Practice

ICAO ENVIRONMENTAL TECHNICAL MANUAL ON THE USE OF
PROCEDURES IN THE NOISE CERTIFICATION OF AIRCRAFT

November 1985

SECTION 1: GENERAL

1.1 Purpose

The aim of this technical manual is to promote uniformity of implementation of the technical procedures of Annex 16, Volume 1, and to provide guidance such that all certificating authorities can apply the same degree of stringency and the same criteria for acceptance in approving applications for the use of equivalent procedures.

This manual provides guidance in the wider application of equivalent procedures that have been accepted as the technical means for demonstrating compliance with the noise certification requirements of Annex 16, Volume 1. Such procedures are referred to Annex 16, Volume 1, but are not dealt with in the same detail as in the Appendices of the Annex which describe the noise evaluation methods for compliance with the relevant Chapters.

Annex 16, Volume 1, procedures must be used unless an equivalent procedure is approved by the certificating authority. Equivalent procedures should not be considered as limited only to those described herein, as this technical manual will be expanded as new procedures are developed.

1.2 Framework

Equivalent procedures fall into two broad categories; those which are generally applicable and those which are applicable to a particular aircraft type. For example, some equivalencies dealing with measurement equipment may be used for all types of aircraft, but a given test procedure may only be appropriate for turbojet powered aeroplanes, and not to turboprop powered aeroplanes. Consequently this manual is framed to provide information on equivalent procedures applicable to the types of aircraft covered by Annex 16 Volume 1, i.e., jet powered, propeller driven heavy and light aeroplanes and helicopters. Equivalent procedures applicable to each aircraft type are identified in separate sections. Each section covers, in the main, flight test equivalencies, the use of analytical procedures and equivalencies in evaluation procedures.

1.3 Incorporation of Equivalent Procedures into the Noise Compliance Demonstration Plan

Prior to undertaking a noise certification demonstration, the applicant is normally required to submit to the certificating authority a noise compliance demonstration plan. This plan contains the method by which the applicant proposes to show compliance

with the noise certification requirements. Approval of this plan and the proposed use of any equivalent procedure remains with the certificating authority. The procedures in this manual are grouped for specific applications. The determination of equivalency for any procedure or group of procedures must be based upon the consideration of all pertinent facts relating to the application for a certificate.

Use of equivalent procedures may be requested by certificate applicants for many reasons, such as:-

- a) to make use of previously acquired certification test data for the aeroplane type;
- b) to permit and encourage more reliable demonstration of small noise level differences among derived versions of an aeroplane type;
- c) to minimize the costs of demonstrating compliance with the requirements of Annex 16, Volume 1, by keeping aircraft test time, airfield usage, and equipment and personnel costs to a minimum.

The material included in this manual is for technical guidance only. The use of past examples of approved equivalencies does not imply that these equivalencies are the only acceptable ones, neither does their presentation imply any form of limitation of their application, nor does it imply commitment to further use of these equivalencies.

1.4 Changes to the Noise Certification Levels for Derived Versions

Many of the equivalent procedures given in this manual relate to derived versions, where the procedure used yields the information needed to obtain the noise certification levels of the derived version by adjustment of the noise levels of the "flight datum" aircraft (i.e, the most appropriate aircraft for which the noise levels were measured during an approved Annex 16, Volume 1, flight test demonstration).

The physical differences between the "flight datum" aircraft and the derived version can take many forms, for example, an increased take-off weight, an increased engine thrust, changes to the powerplant or propeller or rotor types, etc. Some of these will alter the distance between the aircraft and the noise certification reference points, others the noise source characteristics. Procedures used in the determination of the noise certification levels of the derived versions will therefore depend upon the change to the aircraft being considered. However, where several similar changes are being made, for example, introduction of engines from different manufacturers, the procedures used to obtain the noise certification levels of each derivative aircraft should be followed in identical fashion.

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at least to noise levels **10 dB** below the maximum tone corrected Perceived Noise Level (**PNLTM**) obtained at the measurement points during the demonstration.

2.1.2 Generalised flight test procedures

The following equivalent flight test procedures have been used for noise certification compliance demonstrations.

2.1.2.1 Derivation of noise, power, distance data

For a range of powers covering full take-off and cut-back powers, the **aeroplane** is flown past lateral and under-flight-path microphones in accordance with paragraphs **3.6.2.1 c) d)** of Annex **16**, Volume **1**. A sufficient number of noise measurements are made to enable noise-power curves at a given distance for both lateral and flyover cases to be established. These curves are extended either by calculation or by the use of additional flight test data to cover a range of distances to form the **generalised** noise data base for use in the noise certification of the "flight datum" and derived versions of the type and are often referred to as Noise-Power-Distance (**NPD**) plots. (See Fig. **2**). The **90%** confidence **intervals** about the mean lines are constructed through the data (see paragraph **2.2** of Appendix **1**). This is repeated for an under flight path microphone for a range of approach powers using the speed and **aeroplane** configuration given in paragraph **3.6.3** of Annex **16**, Volume **1**.

Availability of flight test data for use in data adjustment, **eg** speed and altitude, should be considered in test planning and may limit the extent to which a derived version may be developed without further flight testing especially where the effects of airspeed on source noise levels become significant.

The take-off, lateral and approach noise measurements should be corrected to the reference speed and atmospheric conditions over a range of distances in accordance with the procedures described in Appendix 1 (Chapter 2 **aeroplanes**) or Appendix 2 (Chapter 3 **aeroplanes**) of Annex **16**, Volume **1**. The **NPD** plots can then be constructed from the corrected Effective Perceived Noise Level (**EPNL**), power and distance information. The curves present the **EPNL** value for a range of distance and engine noise performance **parameters, μ** (see Annex **16**, Volume **1**, paragraph **9.3.4.1** of Appendix **2**). The parameters are **usually** the corrected low pressure rotor speed $N_1/\sqrt{\theta_{t2}}$ or the corrected net thrust F_N/σ_{amb} (see Fig. **2**), **where:-**

N_1 is the actual low pressure rotor speed,
 θ_{t2} is the ratio of absolute static temperature of the air at the height of the **aeroplane** to the absolute temperature of the air for an international standard atmosphere (ISA) at mean sea level (i.e., **288.15K**)

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- 2.1.3.1 Lateral noise measurements for a range of conventionally configured aeroplanes with under wing and/or rear-fuselage mounted engines, have shown that the maximum lateral noise at full power normally occurs when the aeroplane is close to 300 m (985 ft) or 435 m (1,427 ft) in height during the take-off. Based on this finding it is considered acceptable to use the following as an equivalent procedure:
- a) for aeroplanes to be certificated under Chapter 3 or Chapter 2 of Annex 16, Volume 1, two microphone locations are used, symmetrically placed on either side of the aeroplane reference flight track and 450 m or 650 m* from it.
 - b) the height of the aeroplane as it passes the microphone stations should be 300 m (985 ft) or 435 m* (1,427 ft) and be no more than +100 m, -50 m (+328 ft, -164 ft) relative to this target height.
 - c) constant power, configuration and airspeed as described in paragraphs 3.6.2.1 a), 3.6.2.1 d), 2.6.1.2 and 2.6.1.3 of Annex 16, Volume 1, should be used during the flight demonstration.
 - d) adjustment of measured noise levels should be made to the acoustical reference day conditions and to reference aeroplane operating conditions as specified in section 9 of Appendix 1* and 2 of Annex 16, Volume 1.
 - e) to account for any possible asymmetry effects in measured noise levels, the reported lateral noise level for purposes of demonstrating compliance with the applicable noise limit of Chapter 3 or Chapter 2 of Annex 16, Volume 1, as applicable, should be the arithmetic average of the corrected maximum noise levels from each of the two lateral measurement points and compliance should be determined within the 1.5 dB 90 percent confidence interval required by the Annex (see paragraph 2.1 of Appendix 1 of this manual).

*for use with Chapter 2 procedures

2.1.4 Take-off flyover noise levels with power cut-back

Flyover noise levels with power cut-back may also be established without making measurements during take-off with full power followed by power reduction in accordance with paragraph 2.2.1 of this manual.

- 2.1.3.1 Lateral noise measurements for a range of conventionally configured aeroplanes with under wing and/or rear-fuselage mounted engines, have shown that the maximum lateral noise at full power normally occurs when the aeroplane is close to 300 m (985 ft) or 435 m (1,427 ft) in height during the take-off. Based on this finding it is considered acceptable to use the following as an equivalent procedure:
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2.1.4 Take-off flyover noise levels with power cut-back

Flyover noise levels with power cut-back may also be established without making measurements during take-off with full power followed by power reduction in accordance with paragraph 2.2.1 of this manual.

- c) aeroplane engine and nacelle configuration and acoustical treatment changes, usually leading to changes in EPNL of less than one decibel. However, it should be ensured that new noise sources are not introduced by modifications made to the aeroplane, engine or nacelles.
- d) airframe design changes such as changes in fuselage length, flap configuration and engine installation, that could indirectly affect noise levels because of an effect on aeroplane performance (increased drag for example). Changes in aeroplane performance characteristics derived from aerodynamic analysis or testing have been used to demonstrate how these changes affect the aeroplane flight path and hence the demonstrated noise levels of the aeroplane.

In these cases care should be exercised to ensure that the airframe changes do not introduce significant new noise sources nor modify existing source generation or radiation characteristics. In such instances the magnitude of such effects may need to be established by test.

2.3 Static Tests and Projections to Flight Noise Levels

Static test evidence provides valuable definitive information for deriving the noise levels resulting from changes to an aeroplane powerplant or the installation of a broadly similar powerplant into the airframe following initial noise certification of the flight datum aeroplane. This involves the testing of both the flight datum and derivative powerplants using an open-air test facility whereby the effect on the noise spectra of the engine modifications in the aeroplane may be assessed. It can also extend to the use of component test data to demonstrate that the noise levels remain unchanged where minor development changes have been made.

Approval of equivalent procedures for the use of static test information depends critically upon the availability of an adequate approved data base (NPD plot) acquired from the flight testing of the flight datum aeroplane.

Static tests can provide sufficient additional data or noise source characteristics to allow a prediction to be made of the effect of changes on the noise levels from the aeroplane in flight.

Types of static test accepted for the purposes of certification compliance demonstration in aeroplane development include engine and component noise tests and performance testing. Such tests are useful for assessing the effects of mechanical and thermodynamic cycle changes to the engine on the individual noise sources.

Static engine testing is dealt with in detail in subsequent sections. The criteria for acceptance of component tests are less definable. There are many instances, particularly when only small EPNL changes are expected, that component testing provides an adequate demonstration of noise impact. These include, for example:

- a) changes in the specification of sound absorbing linings within an engine nacelle,
- b) changes in the mechanical or aerodynamic design of the fan, compressor or turbine,
- c) changes to combustor designs.
- d) minor exhaust system changes.

Each proposal by the applicant to use component test data should be considered by the certificating authority with respect to the significance of the relevant affected source on the EPNL of the aeroplane.

2.3.1 Limitation on the projection of static to flight data

Details of the acceptability, use and applicability of static test data are contained in subsequent sections.

The amount by which the measured noise levels of a derivative engine will differ from the reference engine is a function of several factors, including:

- (a) thermodynamic changes to the engine cycle, including increases in thrust;
- (b) design changes to major components, e.g., the fan, compressor, turbine, exhaust system, etc;
- (c) changes to the nacelle.

Additionally, day-to-day and test site-to-site variables can influence measured noise levels and therefore the test, measurement and analysis procedures described in this manual are designed to account for these effects. In order that the degree of change resulting from aspects such as (a), (b) and (c) above, when extrapolated to flight conditions, are constrained to acceptable amounts before a new flight test is required, a limit is needed that can be used uniformly by certificating authorities.

The recommended guideline for this limit is that the summation of the magnitudes, neglecting signs, of the noise changes, for the three reference certification conditions, between the flight datum aeroplane and the derived version, at the same thrust and distance (for the derived version), is no greater than 5 EPNdB with a maximum of 3 EPNdB at any one of the reference conditions (see figure 5).

For differences greater than this additional flight testing at conditions where noise levels are expected to change is recommended to establish a new flight NPD data base.

However, provided the detailed prediction procedures used are verified by flight test for all the types of noise sources i.e. tones, non-jet broadband and jet noise relevant to the **aeroplane** under consideration and there are no significant changes in installation effects between the **aeroplane** used for the verification of the prediction procedures and the **aeroplane** under consideration, the procedure may be employed without the limitations described above.

In the determination of the noise levels of the modified or derived version the same analytical procedures as used in the first static to flight calculations for the noise certification of the **aeroplane** type shall be used.

2.3.2 Static Engine Tests

Data acquired from static tests of engines of similar designs to those that were flight tested may be projected, when appropriate, to flight conditions and, after approval, used to supplement an approved **NPD** plot for the purpose of demonstrating compliance with the Annex 16, Volume 1, provisions in support of a change in type design. This section provides guidelines on static engine test data acquisition, analysis and **normalisation** techniques. The information provided is used in conjunction with technical considerations and the general guidelines for test site, measurement and analysis instrumentation, and test procedures provided in the latest version of the Society of Automotive Engineers (**SAE**) **AIR 1846-1984**, "Measurement of Noise from Gas Turbine Engines During Static Operation". The engine designs and the test and analysis techniques to be used should be presented in the test plan and submitted, for approval, to the certificating authority for concurrence prior to testing. Note that test restrictions defined for flight testing in conformity with Annex 16, Volume 1, are not necessarily appropriate for static testing. (**SAE AIR 1846-1984** provides guidance on this subject).

For example, the measurement distances associated with static tests are substantially less than those encountered in flight testing and may permit testing in atmospheric conditions not permitted for flight testing by Annex 16, Volume 1. Moreover, since static engine noise is a steady sound pressure level rather than the transient noise level of a flyover, the measurement and analysis techniques may be somewhat different for static noise testing.

2.3.2.1 Test site requirements

The test site should meet at least the criteria specified in **SAE AIR 1846-1984**. Different test sites may be selected for testing differing engine configurations provided the acoustic measurements from the different sites can be adjusted to a common reference condition.

2.3.2.2 Measurement and analysis

Measurement and analysis systems used for static test, and the modus operandi of the test programme, may well vary according to the specific test objectives, but in general they should conform with those outlined in **SAE AIR 1846-1984**. Some important factors to be taken into account are highlighted in subsequent sections.

2.3.2.3 Microphone locations

Microphones should be located over an angular range sufficient to include the **10 dB** down times after projection of the static noise data to flight conditions. General guidance in **SAE AIR 1846**, describing microphone locations is sufficient to ensure adequate definition of the engine noise source characteristics.

The choice of microphone location with respect to the test surface depends on the specific test objectives and the methods to be used for data **normalisation**. Certification experience with static engine testing has been primarily limited to microphone installations near the ground or at engine centreline height. In general, because of the difficulties associated with obtaining free-field sound pressure levels that are often desirable for extrapolating to flight conditions, **near-ground-plane** microphone installations or a combination of ground-plane and elevated microphones have been used. Consistent microphone locations, heights, etc. are recommended for noise measurements of both the prior approved and changed version of an engine or nacelle.

2.3.2.4 Acoustic shadowing

Where ground plane microphones are used, special precautions are necessary to ensure that consistent measurements, e.g., free from "acoustic shadowing" (refraction) effects, will be obtained. When there is a wind in the opposite direction to the sound wave propagating from the engine, or when there is a substantial thermal gradient in the test arena, refraction can influence near-ground plane microphone measurements to a larger degree than measurements at greater heights.

Previous evidence, or data from a supplemental test, may be used to demonstrate that testing at a particular test site results in consistent measurements, including the absence of shadowing. In lieu of this evidence, a supplemental noise demonstration test should include an approved method to indicate the absence of shadowing effects on the ground plane measurements.

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2.3.2.5 Engine power test conditions

A range of static engine operating conditions should be selected to correspond to the expected maximum range of in-flight engine operating conditions for the appropriate engine power setting parameter. A sufficient number of stabilised engine power settings over the desired range should be included in the test to ensure that the 90% confidence intervals in flight projected EPNL can be established (see paragraph 3 of Appendix 1 to this manual).

2.3.2.6 Data system compatibility

The data acquisition and analysis systems should comply with the recommendations given in SAE AIR 1846. If more than one data acquisition and analysis system is used for the acquisition of static data, compatibility of the two systems is necessary and can be accomplished through appropriate calibration.

The use of a pseudo random noise signals is an acceptable alternative to using actual engine noise measurements for analysis system compatibility determination. The analysis system differences should be adjusted on a one-third octave basis.

2.3.2.7 Data acquisition, analysis and normalisation

For each engine power setting designated in the test plan, the engine performance, meteorological and sound pressure level data should be acquired and analysed using instrumentation and test procedures described in SAE AIR 1846-1984. Sound measurements should be normalised to consistent conditions and include 24 1/3-octave band sound pressure levels between band centre frequencies of 50 Hz to 10 KHz for each measurement (microphone) station. Before projecting the static engine data to flight conditions, the sound pressure level data should be corrected for:-

- (a) the frequency response characteristics of the data acquisition and analysis system.
- (b) contamination by background ambient or electrical system noise. (See Appendix 3)

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fuselage scattering or airframe reflection effects. However, general methods to adjust for these effects are not yet available. It is therefore important that, before the following procedures are approved for the derived version of the **aeroplane**, the geometry of the airframe and engines in the vicinity of the engines be shown to be essentially identical to that of the flight datum **aeroplane** so that the radiated noise is essentially **unaffected**.

2.3.3.1 Normalisation to reference conditions

The **analysed** static test data should be **normalised** to freefield conditions in the Annex 16, Volume 1 reference atmosphere. This adjustment can only be applied with a knowledge of the total spectra being the summation of all the noise source spectra computed as described in paragraphs 2.3.3.2 to 2.3.3.4.

The required adjustments include:

- (1) Atmospheric absorption - adjustments to account for the acoustical reference day atmospheric absorption are defined in **SAE ARP 866A** (revised 15th March 1975). In the event that minor differences in absorption values are found in **SAE ARP 866A** between equations, tables or **graphs**, the equations should be used.

The atmospheric absorption should be computed over the actual distance from the effective **centre** of each noise source to each microphone, as determined in 2.3.3.4.

- (2) Ground reflection - examples of methods for obtaining freefield sound pressure levels are described in **SAE AIR 1672B-1983** or Engineering Sciences Data Unit, **ESDU Item 80038** Amendment A.

Spatial distribution of noise sources do not have a first order influence on ground reflection effects and hence may be disregarded. It is also noted that measurements of far-field sound pressure levels with ground-plane microphones may be used to avoid the large spectral irregularities caused by interference effects at frequencies less than 1 **KHz**.

2.3.3.2 Separation into broadband and tone noise

The purpose of procedures described in this section is to identify all significant tones in the spectra, firstly to ensure that tones are not included in the subsequent estimation of broadband noise, and secondly to enable the Doppler-shifted tones (**in-**

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- (1) For single-stream engines with circular nozzles, the procedure detailed in SAE ARP 876C-1985 may be used. However, the engine geometry may possess features which can render this method inapplicable. Example procedures for co-axial flow engines are provided in SAE AIR 1905-1985.
- (2) Analytical procedures based on correlating full scale engine data with model nozzle characteristics may be used. Model data have been used to supplement full scale engine data, particularly at low power settings, because of the uncertainty in defining the level of jet noise at the higher frequencies where noise from other engine sources may make a significant contribution to the broadband noise.
- (3) Special noise source location techniques are available which, when used during full-scale engine tests, can identify the positions and levels of separate engine noise sources.

2.3.3.4 Noise source position effects

Static engine noise measurements are often made at distances at which engine noise sources cannot be truly treated as radiating from a single acoustic centre. This may not give rise to difficulties in the extrapolation to determine the noise increments from static data to flight conditions because noise increments in EPNL are not particularly sensitive to the assumption made regarding the spatial distribution of noise sources.

However, in some circumstances (for example, where changes are made to exhaust structures, and the sources of external jet-mixing noise are of overriding significance) it may be appropriate to identify noise source positions more accurately. The jet noise can be considered as a noise source distributed downstream of the engine exhaust plane. Internal sources of broadband engine noise may be considered as radiating from the intake and the exhaust.

There are three principal effects to be accounted for as a consequence of the position of the noise source differing from the "nominal" position assumed for the "source" of engine noise.

- (1) Spherical divergence - the distance of the source from the microphone differs from the nominal distance; an inverse square law adjustment needs to be applied.
- (2) **Directivity** - the angle subtended by the line from the source to the microphone and the source to the engine centreline differs from the nominal angle; a linear interpolation should be made to obtain data for the proper angle.
- (3) Atmospheric attenuation - the difference between the true and the nominal distance between the source and the microphone alters the allowance made for atmospheric attenuation in paragraph 2.3.3.1 above.

Source position can be identified either from noise source location measurements (made either at full or model scale), or from a **generalised** data base.

Note: No published standard on coaxial jet noise source distribution is currently available. An approximate distribution for a single jet is given by the following equation (see **Ref 1** and 2):-

$$x/D = (0.057S + 0.021S^2)^{-\frac{1}{2}}$$

where S is the **Strouhal** number fD/V_j
 x is the distance downstream from the nozzle exit
 D is the nozzle diameter based on total nozzle exit area
 V_j is the average jet velocity for complete isentropic expansion to ambient pressure from average nozzle-exit pressure and temperature
 f is the **1/3** octave **centre** frequency

2.3.3.5 Engine flight conditions

Some thermodynamic conditions within an engine tested statically differ from those that exist in flight and account should be taken of this. Noise source strengths may be changed accordingly. Therefore, values for key correlating parameters for component noise source generation should be based on the flight condition and the static data base should be entered at the appropriate correlating parameter value. Turbo-machinery noise levels should be based on the **inflight** corrected rotor speeds $N_1/\sqrt{\theta} t_2$ and jet noise levels should be based on the relative jet velocities that exist at the flight condition.

The variation of source noise levels with key correlating parameters can be determined from the static data base which includes a number of different thermodynamic operating conditions.

- (1) Spherical divergence - the distance of the source from the microphone differs from the nominal distance; an inverse square law adjustment needs to be applied.
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The variation of source noise levels with key correlating parameters can be determined from the static data base which includes a number of different thermodynamic operating conditions.

It should be noted that for those 1/3 octave band sound pressure levels dominated by a turbomachinery tone, the Doppler shift may move the tone (and its harmonics) into an adjacent band.

- (2) Source amplitude modification and directivity changes - sound pressure level adjustments to airframe generated noise that result from speed changes between the datum and derivative version is provided for in paragraph 2.3.3.8, Airframe noise.

For noise generated internally within the engine, e.g., fan noise, there is no consensus of opinion on the mechanisms involved or a unique adjustment method that accounts for the detailed source modification and sound propagation effects.

If an adjustment is used, the same technique must be applied to both the flight datum and derivative configuration when establishing noise changes. In such instances the adjustment for sound pressure level changes that result from the motion of the source (aeroplane) relative to the microphone may be accounted for using the equation:

$$SPL_{flight} = SPL_{static} - K \log(1 - M \cos \lambda)$$

where SPL_{flight} = flight sound pressure level
 SPL_{static} = static sound pressure level
 and M and λ are defined above and K is a constant. Theoretically K has a value of 40 for a point noise source but a more appropriate value may be obtained by comparing static and flight data for the flight datum aeroplane.

2.3.3.7 Aeroplane configuration effects

The contribution from more than one engine on an aeroplane is normally taken into account by adding $10 \log_{10} N$, where N is the number of engines, to each component noise source. However, it might be necessary to compute the noise from engines widely spaced on large aeroplanes particularly in the approach case if they include both underwing and fuselage mountings. The noise from the intakes of engines mounted above the fuselage are known to be shielded.

If engine installation effects change between the flight datum aeroplane and a derived version, account should be taken of the change on sound pressure levels which should be estimated according to the best available evidence.

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If engine installation effects change between the flight datum aeroplane and a derived version, account should be taken of the change on sound pressure levels which should be estimated according to the best available evidence.

The effects of ground reflections must be included in the estimate of freefield sound pressure levels to simulate the sound pressure levels that would be measured by a microphone at a height of 1.2 m above a natural terrain. Information in **SAE AIR 1672B-1983** or Engineering Science Data Unit, **ESDU** data item **80038** Amendment A may be used to apply adjustments to the freefield spectra to allow for flight measurements being made 1.2 m (4ft). Alternatively, the ground reflection correction can be derived from other approved analytical or empirically derived models. Note that the Doppler correction for a static source at frequency f_{static} applies to a moving (**aeroplane**) source at a frequency f_{flight} where $f_{\text{flight}} = f_{\text{static}} / (1 - M \cos \Lambda)$ using the terminology of 2.3.3.6, b(1).

This process is repeated for each measurement angle and for each engine power setting.

With regard to lateral attenuation, information in **SAE AIR 1751-1981** applicable to the computation of lateral noise may be applied.

2.3.3.11 EPNL computations

For **EPNL** calculations, a time is associated with each extrapolated spectrum along the flightpath. (NOTE: Time is associated with each measurement location with respect to the **engine/aeroplane** reference point and the **aeroplane's** true airspeed along the reference flightpath assuming zero wind). For each engine power setting and minimum distance, an **EPNL** is computed from the projected time history using the methods described in Annex 16, Volume 1, Appendices 1 and 2.

2.3.3.12 Changes to noise levels

An **NPD** plot can be constructed from the projected static data for both the original (flight datum) and the changed versions of the engine or nacelle tested. Comparisons of the noise **vs** engine power relationships for the two configurations at the same appropriate minimum distance, will determine whether or not the changed configuration resulted in a change to the noise level from an engine noise source. If there is a change in the level of source noise, a new **inflight aeroplane NPD** plot can be developed by adjusting the measured original **NPD** plot by the amount of change indicated by the comparison of the static-projected **NPD** plots for the original and changed versions within the limitations specified in 2.3.1 for Effective Perceived Noise Level.

The noise certification levels for the derived version may be obtained by entering the **NPD** plots at the relevant reference engine power and distance.

SECTION 3: EQUIVALENT PROCEDURES FOR PROPELLER DRIVEN AEROPLANES OVER 9 000 kg

The following procedures have been used as equivalent in stringency to Chapter 5 Annex 16, Volume 1 for propeller driven aeroplanes with maximum certificated take-off mass exceeding 9 000 kg.

3.1 Flight Test Procedures

- 3.1.1 Flight path intercept procedures in lieu of full take-offs and/or landings, flight path intercept procedures as described in 2.1.1 of this manual have been used to meet the demonstration requirements of noise certification.
- 3.1.2 Generalised flight test procedures (other than normal noise demonstration takeoffs and approaches) have been used to meet two equivalency objectives:
 - a) to acquire noise data over a range of engine power settings at one or more heights: this information permits the development of generalised noise characteristics necessary for certification of a "family" of similar aeroplanes. The procedures used are similar to those described in 2.1.2.1 with the exception that the NPD plots employ engine noise performance parameters (μ) of M_T (propeller helical tip Mach number) and SHP/ϕ_{amb} (shaft horse power) (see Fig 3) where ϕ_{amb} is defined in 2.1.2.1.
 - b) Noise level changes determined by comparisons of fly-over noise test data for different developments of an aeroplane type, for example, a change in propeller type, have been used to establish certification noise levels of a newly derived version as described in 2.1.2.2.
- 3.1.3 Determination of the lateral noise certification level employing an alternative procedure using two microphone stations located symmetrically on either side of the take-off flight path similar to that as described in 2.1.3 has been approved. The following paragraphs describe the procedures for propeller-driven heavy aeroplanes.
 - 3.1.3.1 The lateral Effective Perceived Noise Level from propeller driven aeroplanes when plotted against height opposite the measuring sites can exhibit distinct asymmetry. The maximum EPNL on one side of the aeroplane is often at a different height and noise level from that measured on the other side.

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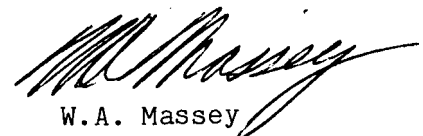
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From: The Chairman, First Meeting of the Committee
on Aviation Environmental Protection (CAEP/1)

I have the honour to submit the Report of the First Meeting of the ICAO Committee on Aviation Environmental Protection (CAEP/1) held in Montreal, from 9 - 20 June 1986.



W.A. Massey
Chairman

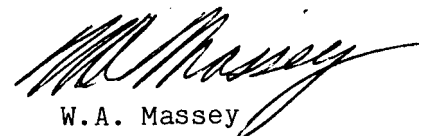
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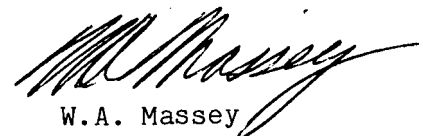
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Agenda Item 4: Aircraft Engine Emissions

Review of the report of the focal point with a view to developing future course of action.

Agenda Item 5: Future activities of the Committee6. Terms of reference

To undertake specific studies, as approved by the Council, related to control of aircraft noise and gaseous emissions from aircraft engines.

In its work the Committee shall take into account the following:

- a) effectiveness and reliability of certification schemes from the viewpoint of technical feasibility, economic reasonableness and environmental benefit to be achieved;
- b) developments in other associated fields, e.g. land use planning , noise abatement operating procedures, emission control through operational practices, etc; and
- c) international and national programmes of research into control of aircraft noise and control of gaseous emissions from aircraft engines.

7. Work ProgrammeA. AIRCRAFT NOISE1. Noise certification of helicopters

- a) Further development of noise certification Standards and procedures including review of technological development, examination of practicability and economic reasonableness of increasing stringency for different types of helicopters including their derived versions and further development of test procedures including equivalent procedures.
- b) Analysis of noise certification data collected from States on helicopters.

2. Noise certification of propeller-driven aeroplanes

- a) Further development of proposed new Chapter "X" and the associated Appendix "X" for possible application to future light propeller-driven aeroplanes.
- b) Analysis of noise certification data collected from States on propeller-driven aeroplanes.

3. Noise certification of subsonic jet aeroplanes

Further development of noise certification Standards and procedures, including examination of practicability, benefits and economic reasonableness of increasing stringency for different types of subsonic jet aeroplanes, exemption of aeroplanes designed and/or modified for special tasks, further development of test procedures including equivalent procedures and development of noise exposure contour methodology.

B. AIRCRAFT ENGINE EMISSIONS

- a) keep under review air quality justifications for any further control of emissions from aircraft in the vicinity of airports, including the review of the means by which this justification may be determined;
- b) where such air quality justifications are determined to exist, propose appropriate provisions for the control of emissions from aircraft in the vicinity of airports or amendments to such existing provisions;
- c) review developments in technology which may justify the introduction or amendment of provisions for the control of emissions from aircraft and propose appropriate provisions or amendments to existing provisions accordingly;
- d) monitor international and national programmes of research into pollution of the atmosphere above 900 metres and propose appropriate action if it appears that aircraft are significant contributors to this pollution; and
- e) recommend to the Council the addition of any other items on which the Committee considers useful work could be done.

8. Working arrangements

All items of the agenda were dealt with by the Committee as a whole. Various ad hoc groups were set up to deal with specific matters.

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3. Noise certification of subsonic jet aeroplanes

Further development of noise certification Standards and procedures, including examination of practicability, benefits and economic reasonableness of increasing stringency for different types of subsonic jet aeroplanes, exemption of aeroplanes designed and/or modified for special tasks, further development of test procedures including equivalent procedures and development of noise exposure contour methodology.

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- d) monitor international and national programmes of research into pollution of the atmosphere above 900 metres and propose appropriate action if it appears that aircraft are significant contributors to this pollution;
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- e) recommend to the Council the addition of any other items on which the Committee considers useful work could be done.

8. Working arrangements

All items of the agenda were dealt with by the Committee as a whole. Various ad hoc groups were set up to deal with specific matters.

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Agenda Item 1: Noise certification of helicopters

Further development of noise certification Standards and procedures including review of technological development, examination of practicability and economic reasonableness of increasing stringency for different types of helicopters including their derived versions and further development of test procedures including equivalent procedures.

1.1 Introduction

1.1.1 Working Group II was established by the Committee to consider the further development of noise standards introduced during the Seventh Meeting of the Committee on Aircraft Noise (CAN). The Working Group was asked to study and report to the Committee on the following:

- a) The possibility of further development of noise certification Standards with a view to increasing their stringency within the constraints of technical feasibility and economic reasonableness.
- b) The development of methods to evaluate residual factors and design uncertainties which have a particular impact on noise level requirements.
- c) The prospects for improving on noise test specifications and on the methodology for analysis and adjustment of noise test data.
- d) The identification of equivalent procedures for inclusion in Attachment B of Annex 16, Volume I.
- e) The collection and analysis of noise certification quality data and historical economic data to assess methodologies developed by CAN.
- f) Noise abatement and/or alternative test procedures appropriate for aircraft operations and development of standards in liaison with ICAO operational panels.

1.1.2 A comprehensive report on its investigations was prepared by the Working Group and presented to the Committee during CAEP/1. The Committee also had before it several related working papers prepared by individual members or observers which addressed specific aspects of some of the tasks assigned to the Working Group. The following paragraphs reflect the results of the Committee's discussions on the Working Group report and the various working papers.

1.2 Discussion1.2.1 General

The Committee noted that Working Group II had held three technical meetings prior to CAEP/1. During those meetings, 49 working papers and 58

information papers were presented for consideration. In addition, a subgroup meeting was held for the purpose of analyzing test results obtained under the Helicopter Noise Measurement Repeatability Program (HNMRP) conducted by eight participating member States. Finally, a fourth meeting completed drafting of the final report of the Working Group. The Committee acknowledged the excellent work done by all of the members of the Working Group in discharging their tasks and thanked in particular the group's rapporteur, Mr. J.O. Powers and Mr. S. Newman for their outstanding efforts.

1.2.2 The helicopter programme

1.2.2.1 Flight test noise data

Flight test noise data for the compilation of a helicopter noise data base have been generated from several sources since the CAN/7 meeting. Some Working Group members have conducted flight test programmes for comparison of the noise level measured data with the Annex 16, Chapter 8 Standards. In this category a limited amount of data was received in response to the CAN/7 Recommendation 1/4, which requested ICAO members to present noise data for helicopters using the recommended format developed during CAN/7. A substantial amount of flight-test data has been acquired in the conduct of the structured repeatability tests and tests for the assessment of noise abatement operating procedures which are discussed in Sections 1.2.2.2 and 1.2.2.4 below. Additionally, flight tests data have been acquired from test programmes designed specifically to explore the prospects for alternative test procedures in accordance with the Terms of Reference.

1.2.2.1.1 Data for assessment of Standards

The majority of the data that are suitable for comparison with the Annex 16 noise level Standards was submitted in response to Recommendation 1/4 of the CAN/7 meeting. The data are tabulated in Table 1.1 and presented graphically in Figure 1.1. It is noted that twenty-four individual helicopters are represented. Additional data points may be available as further analysis of test data from flight test programmes becomes available and as ICAO member nations implement the Annex 16, Chapter 8 Standards. The Committee agreed on a revised format for the data collection sheet to include fly-over height after take-off, as indicated in Attachment C, which is to be used in the future.

1.2.2.1.2 Alternate test procedures

- a) At CAN/7 the Committee considered examination of alternate flight procedures to be an appropriate area for investigation. The concept originated as a result of anticipated difficulties in meeting the approach noise level limits. These difficulties were expected because of the high probability of an impulsive noise component resulting from the blade-vortex interaction during the 6 degree approach test. Since approaches to heliports would not

information papers were presented for consideration. In addition, a subgroup meeting was held for the purpose of analyzing test results obtained under the Helicopter Noise Measurement Repeatability Program (HNMRP) conducted by eight participating member States. Finally, a fourth meeting completed drafting of the final report of the Working Group. The Committee acknowledged the excellent work done by all of the members of the Working Group in discharging their tasks and thanked in particular the group's rapporteur, Mr. J.O. Powers and Mr. S. Newman for their outstanding efforts.

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standards and would, because of the additional test runs required, constitute an unnecessary economic burden. Another member pointed out that in his State, if a helicopter failed to meet the noise standards at any of the approach angles, it would not be allowed to operate under those conditions. After some discussion, during which industry representatives accepted the additional burden in the interest of refining the Standard, changes to the wording of the alternative method material were accepted and the Committee agreed to the proposed guidelines as amended. Accordingly, it is recommended that guidance material in Attachment A to this part of the report be included in Annex 16 to encourage States to evaluate this alternative method of establishing compliance with the approach test requirements. However, consideration of this and other procedures could be continued as part of a future work programme for Working Group II.

1.2.2.1.3 Impulsive signal record problems

- a) A technical issue related to helicopter noise measurement was raised at the WG II/1 meeting. One member suggested that flight-test noise data, in general, would be subject to inaccuracies resulting from signal clipping because of the impulsive character of helicopter noise. This issue was investigated independently and the findings of the investigation were reported to the WG II/2 meeting. Specifically, it was evaluated by exploring the low-frequency characteristics of tape recorders in response to large amplitude sine wave pulses at varied repetition rates which resulted in high crest factors (i.e., as large as 24 dB) simulating helicopter blade-vortex interaction noise.
- b) A direct record Nagra IVSJ and an FM record B&K 7005 magnetic tape recorder were used in the investigation. The signals were simultaneously recorded by each recorder and reproduced using an oscilloscope to monitor the waveforms and an FFT narrowband analyzer to determine the power spectrum of the signals. The input and output signal waveforms were compared, and while no deterioration was observed, the Nagra output was shifted 180 degrees in phase. The power spectrum data indicated that the reproduced signal was not affected by the phase distortion. The RMS level of the reproduced signal for four 1/3-octave bands and for the energy-summed overall levels agreed within 0.2 dB at all test frequencies and crest factors ranging from 10 to 24 dB. It was concluded that although the low frequency non-linear phase response of the direct record tape recorders can alter the signal phase relationship, either the direct record or FM recorders are completely adequate for certification measurements of impulsive

standards and would, because of the additional test runs required, constitute an unnecessary economic burden. Another member pointed out that in his State, if a helicopter failed to meet the noise standards at any of the approach angles, it would not be allowed to operate under those conditions. After some discussion, during which industry representatives accepted the additional burden in the interest of refining the Standard, changes to the wording of the alternative method material were accepted and the Committee agreed to the proposed guidelines as amended. Accordingly, it is recommended that guidance material in Attachment A to this part of the report be included in Annex 16 to encourage States to evaluate this alternative method of establishing compliance with the approach test requirements. However, consideration of this and other procedures could be continued as part of a future work programme for Working Group II.

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TABLE 1.1

HELICOPTERS

HELICOPTER			ENGINE (S)		ROTORS. MAIN/TAIL			MEASUREMENTS							MISC.
MANUFACTURER	TYPE	MTOM (kg)	MANUFACTURER	NO.		MAIN DIAM.		DATE		0.9VH (M/S)	VY (M/S)	TO. EPNdB	F.O. EPNdB	L. EPNdB	REMARKS
YEAR OF 1ST C.A.	MODEL	MLM (kg)	MODEL	MTOP (KU)	NO.	TAIL DIAM.	NO. OF BLADES	ORG. RESP.	MEAN TEMP (C)	0.9 VNF (M/S)	V TEST (M/S)	ICAO VALUES EPNdB			INFO TYPE
Agusta 1976	A109 A	2600	Allison 250-C20B	2 313	1/1	11.00 2.030	4/2	5/80 ITALY	25	66.00 73.20	30.90	92.40 94.20	91.80 93.20	93.00 95.20	B
Bell	206L Longranger	1814	Allison 250-C20B	1 313	1/1	11.28 1.580	2/2	6/78 FAA		61.20	26.80	85.90 92.60	85.80 91.60	90.30 93.60	B
Bell	212 H-1	4762	Pratt 6 Whitney PT6A-3	2 481	1/1	14.64 2.590	2/2	6/78 FAA		48.40 46.30	28.30	91.70 96.80	94.60 95.80	95.70 97.80	B
Hughes	500C	1157	Allison 250-C18A	1 298	1/1	8.030 1.300	4/2	6/78 FAA		60.70	25.70	85.10 90.70	85.80 89.70	87.70 91.70	B
MBB-KHI 1982	BK117	2850	Avco Lycoming LTS101-650B-1	2 447	1/1	11.00 1.920	4/2	11/80 Japan	8.3	64.90 68.60	33.50	88.80 94.50	92.60 93.50	90.40 95.50	See WP112/1 A
MES. BO. BM.	BK117 P2	2800	Avco Lycoming LTS101-65C81	2 435	1/1	11.00 1.920	4/2	5/80 FRG/FMT	16	65.00 68.80	33.30 33.30	88.80 94.50	92.50 93.50	90.20 95.50	I Prototype B
MES. BO. BM. 1974	BO105 C	2300 2300	Detroit Diesel All 250-C20	2 298	1/1	9.82 1.900	4/2	8/81 FRG/FMT	16	60.30 66.30	32.00 33.50	89.70 93.60	90.40 92.60	90.60 94.60	Chapter 8 B
HI	MI-26 I	56000 46500	Lotarev D-136	2 8500	1/1	32.00 7.600	8/5	1982 USSR	5	65.00	42.00		106.0 105.7		C
MI	MI-8	12000 11000	Isotov TV2-117A	2 1120	1/1	21.30 3.900	5/3	1981 USSR	17	64.00	34.00	100.0 100.8	97.00 99.80	100.2 101.8	C
Sikorsky	S-61 H-3	10000	General Electric T58-GE-10	2 1044	1/1	18.91 3.150	5/5	6/78 FAA		66.40	38.10	95.90 100.0	92.60 99.00	94.00 101.0	B
Sikorsky	S-65 H-53	16775	General Electric T64	2 2125	1/1	22.02 4.880	6/4	6/78 FAA		66.90	39.10	95.70 102.2	97.10 101.2	99.90 103.2	B

(Cont'd)

TABLE 1.1

HELICOPTERS

HELICOPTER			ENGINE (S)		ROTORS. MAIN/TAIL			MEASUREMENTS							MISC.
MANUFACTURER	TYPE	MTOM (kg)	MANUFACTURER	NO.		MAIN DIAM.	NO. OF BLADES	DATE	MEAN TEMP (C)	0.9VH (M/S)	VY (M/S)	TO. EPNdB	F.O. EPNdB	L. EPNdB	REMARKS
YEAR OF 1ST C.A.	MODEL	MLM (kg)	MODEL	MTOP (KU)		TAIL DIAM.		ORG. RESP.		0.9 VNF (M/S)	V TEST (M/S)	ICAO VALUES EPNdB			INFO TYPE
Agusta 1976	A109 A	2600	Allison 250-C20B	2 313	1/1	11.00 2.030	4/2	5/80 ITALY	25	66.00 73.20	30.90	92.40 94.20	91.80 93.20	93.00 95.20	B
Bell	206L Longranger	1814	Allison 250-C20B	1 313	1/1	11.28 1.580	2/2	6/78 FAA		61.20	26.80	85.90 92.60	85.80 91.60	90.30 93.60	B
Bell	212 H-1	4762	Pratt 6 Whitney PT6A-3	2 481	1/1	14.64 2.590	2/2	6/78 F M		48.40 46.30	28.30	91.70 96.80	94.60 95.80	95.70 97.80	B
Hughes	500C	1157	Allison 250-C18A	1 298	1/1	8.030 1.300	4/2	6/78 F M		60.70	25.70	85.10 90.70	85.80 89.70	87.70 91.70	B
MBB-KHI 1982	BK117	2850	Avco Lycoming LTS101-650B-1	2 447	1/1	11.00 1.920	4/2	11/80 Japan	8.3	64.90 68.60	33.50	88.80 94.50	92.60 93.50	90.40 95.50	See WP112/1 A
MES. BO. BM.	BK117 P2	2800	Avco Lycoming LTS101-65C81	2 435	1/1	11.00 1.920	4/2	5/80 FRG/FMT	16	65.00 68.80	33.30 33.30	88.80 94.50	92.50 93.50	90.20 95.50	I Prototype B
MES. BO. BM. 1974	BO105 C	2300 2300	Detroit Diesel All 250-C20	2 298	1/1	9.82 1.900	4/2	8/81 FRG/FMT	16	60.30 66.30	32.00 33.50	89.70 93.60	90.40 92.60	90.60 94.60	Chapter 8 B
HI	MI-26 I	56000 46500	Lotarev D-136	2 8500	1/1	32.00 7.600	8/5	1982 USSR	5	65.00	42.00		106.0 105.7		C
MI	MI-8	12000 11000	Isotov TV2-117A	2 1120	1/1	21.30 3.900	5/3	1981 USSR	17	64.00	34.00	100.0 100.8	97.00 99.80	100.2 101.8	C
Sikorsky	S-61 H-3	10000	General Electric T58-GE-10	2 1044	1/1	18.91 3.150	5/5	6/78 F M		66.40	38.10	95.90 100.0	92.60 99.00	94.00 101.0	B
Sikorsky	S-65 H-53	16775	General Electric T64	2 2125	1/1	22.02 4.880	6/4	6/78 FAA		66.90	39.10	95.70 102.2	97.10 101.2	99.90 103.2	B

(Cont'd)

TABLE 1.1 (cont.)

HELICOPTER		ENGINES		ROTORS MAIN/TAIL		MEASUREMENTS										MISCELLANEOUS			
Manufacturer	Type	MTOM (Kg)	Manufacturer	Type	Number MTOP (kW)	No.	Diameter (m)	Number of blades	Max. operating speed (RPM)		Date	Mean Temp. (C°)	0.9 VH (m/s)	Vy (m/s)	T.O. EPNdB	F.O. EPNdB	L. EPNdB	Remarks (performance at 150C)	Type of information
									T.O.	Fly over Land			0.9VNE (m/s)	Vmini approx. (m/s)	ICAO limits EPNdB				
Aérospatiale	AS 350B	1900	Turboméca	Arriel IB	1 478	1/1	10,62 1,36	3/2	Nominal 336 tr/mn	13/9/76 30/5/78	13 à 16° 25°	28,2 68	27,8	89,20 92,81	87,2 91,81	91,2 93,81	torquemeter limit 396 kW	B	
Aérospatiale	SA 342L	1900	Turboméca	Astrolon XIV M	1 440	1/1	10,50 0,695	3/13	Nominal 337 tr/mn	24/9/76 30/5/78	13 à 14° 24°	46,1 77,4	36,01	92,81	88,2 91,81	95,5 93,81	Fenestron torquemeter limit 426 kW	B	
Aérospatiale	SA 315B	1950	Turboméca	Arriel III B	1 420	1/1	11,02 1,91	3/3	Nominal 353,2 tr/mn	10 /81	18 à 27°	48 52,5	28,30	94,80 92,92	91,92	93,92	torquemeter limit 440 kW	B	
Aérospatiale	AS 350G	1950	Allison	C30M	1 485	1/1	10,69 1,86	3/2	Nominal 386 tr/mn	14/10/81	20 à 21°	59,2 68	28,29	87,16 92,92	84,3 91,92	87,59 93,92	torquemeter limit 396 kW	B	
Aérospatiale	AS 355F	2300	Allison	C20F	2 478	1/1	10,69 1,86	3/2	Nominal 394 tr/mn	24/6/80	17 à 19°	58,52 69,45	28,29	87,97 93,64	87,63 92,64	92,26 94,64	torquemeter limit 478 kW	B	
Aérospatiale	SA 365N	3800	Turboméca	Arriel IC	1 984	2 1/1	11,93 0,9	4/13	350 362 350	16/6/80	16°	71,3 76,5	36,01	91,3 95,81	90,9 94,81	92,6 96,81	Fenestron main gear box limits 5 min.: 900 kW/cont.: 846 kW	B	
Aérospatiale	SA 365NI	3850	Turboméca	Arriel ICI	2 1052	1/1	11,93 1,1	4/11	352 358 352	8/12/81	10 à 19°	70,3 76,5	38,58	91,60 95,86	90,30 94,86	92,60 96,86	Main gear box limits 5 min.: 900 kW/cont.: 846 kW	B	
Aérospatiale	SA 366G	3950	Lycoming	LTS 101	2 1016	1/1	11,93 0,9	4/13	Nominal 350 tr/mn	9/10/81	19 à 25°	64,82 69,4	38,58	90,1 95,98	88,02 94,98	92,3 96,98	Main gear box limits 5 min.: 900 kW/cont.: 846 kW	B	
Aérospatiale	SA 330J	7400	Turboméca	Turmo IV C	2 2230	1/1	15,03 3,54	4/5	Nominal 265 tr/mn	23/09/76 18/9/78	14° 19 à 20°	64,5 65,75	36,01	97,3 98,70	93,60 97,70	96,10 99,70	torquemeter limit 1810 kW	B	
Aérospatiale	AS 332L	8350	Turboméca	Makila IA	2 2480	1/1	15,60 3,55	4/5	Nominal 265 tr/mn	16/10/81	17 à 22°	69,91 77,32	36,01	99,25 100,22	91,5 98,22	95,1 100,22	torquemeter limit 2235 kW	B	
Aérospatiale	SA 321J	11500	Turboméca	Turmo III C6	3 2850	1/1	18,9 4,00	6/5	Nominal 207 tr/mn	20/9/76 19/12/78	18 à 24° 22°	60,05 76,4	43,72	98,4 100,61	92 99,61	98,6 101,61	torquemeter limit 2520 kW	B	

NOTES

A Measurements for purposes of certification.

B Measurements taken with high quality methods similar to certification, but not conducted specifically for cert. purposes.

C The levels are calculated from general flight tests.

HELICOPTER LEGEND

- | | |
|-----------------------|---------------------------|
| 1. AGUSTA A109 | 13. WESTLAND W30-100 |
| 2. BELL 206L | 14. AEROSPATIALE AS-350B |
| 3. BELL 212 | 15. AEROSPATIAL SA-342L |
| 4. HUGHES 500C | 16. AEROSPATIALE SA-315B |
| 5. MBB-KHI-BK117 | 17. AEROSPATIALE AS-350G |
| 6. MES. BO. BM. BK117 | 18. AEROSPATIALE AS-355P |
| 7. MES. BO. BM. B0105 | 19. AEROSPATIALE SA-365N |
| 8. MI-8 | 20. AEROSPATIALE SA-365NI |
| 9. SIKORSKY S-61 | 21. AEROSPATIALE SA-366G |
| 10. SIKORSKY S-65 | 22. AEROSPATIALE SA-330J |
| 11. SIKORSKY S-76 | 23. AEROSPATIALE AS-332L |
| 12. SIKORSKY UH-60A | 24. AEROSPATIALE SA-321J |

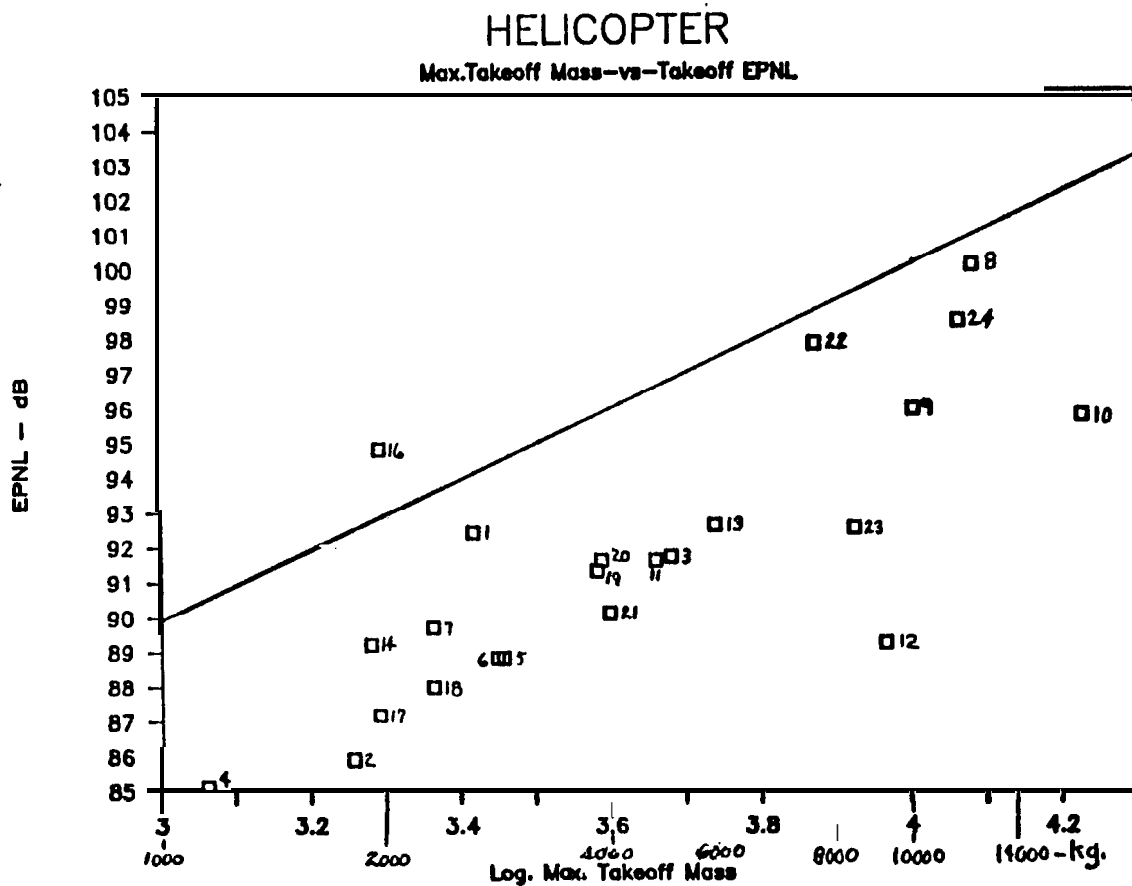


FIGURE 1.1 A

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- | | |
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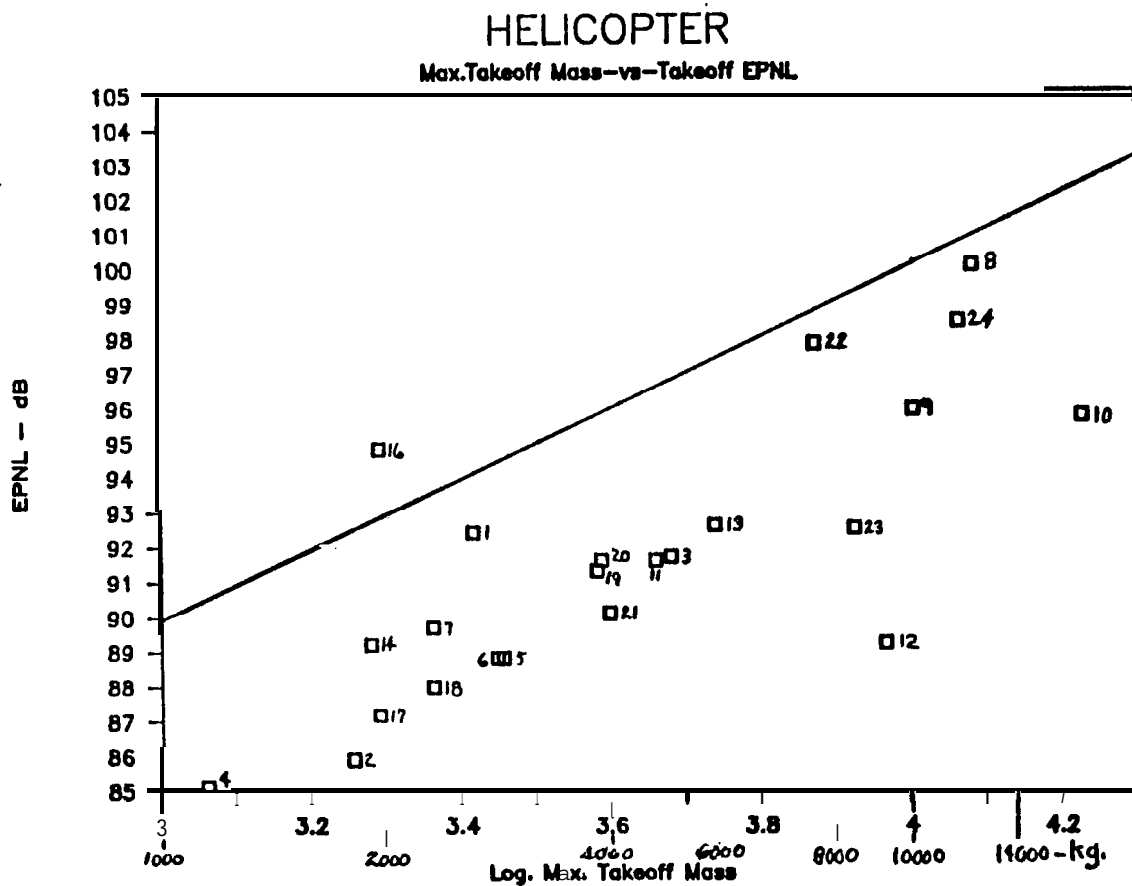


FIGURE 1.1 A

1.2.2.2.2 Programme participants' test results

- a) The helicopter noise measurement repeatability program (HNMRP) was participated in by eight Working Group II member States. Independent programmes were run by Japan and Australia and two-member programme teams were formed by France and Italy, the United Kingdom and the Federal Republic of Germany, and the United States and Canada. All of the member teams performed the core test (i.e., the basic ICAO Chapter 8 test) with the necessary speed runs for source noise determination. In addition to the basic core programme, several of the participants ran static tests for the measurement of helicopter noise in the hovering mode and also explored varied altitude and different landing approach techniques. Some of the programmes additionally utilized more than one helicopter test pilot to observe noise differences which could be attributable to pilot-to-pilot variations in operational technique.
- b) The Australian test programme was conducted using a Bell 206L-1 model at Mangalore Airfield in Victoria, Australia, on September 13 and 14, 1984. Mangalore is approximately 100 km north of Melbourne. Test series included the basic core programme, as well as optional approach operations at 6 and 9 degree glide slopes for a variety of airspeeds. The Australian programme also included additional level flyover series at 150, 250, 300 and 350 metres above ground level. The Australian certificating authorities used the HNMRP participation opportunity to update and refine Annex 16 data processing software. Their programme included use of a relatively novel tracking system (for noise certification purposes) which involved an optical tracker for azimuth and elevation angle along with a DME Mini-Ranger III providing range to the tracking site.
- c) The French-Italian test programme was conducted on a Bell 206L-1 helicopter in October 1984. One Italian and two French laboratories, Aérospatiale and STNA (DGAC), were involved in the measurement programme conducted at La Fare des Oliviers near Marseille. With the Italian Agusta participation and one measurement system deployed by the United States FAA, an opportunity was provided for assessment of the variability of the helicopter noise results by four independent laboratories. The test programme utilized a photo-kinetheodolite tracking system and remote synchronized transport control on all tape recording systems. In addition to the core programme, level flyovers were conducted for various airspeeds and at altitudes of 150 and 250 metres above ground level. The test programme also explored the effects of early rotation during the ICAO take-off operation. Approaches were made at 6, 9 and 12 degrees with different speeds

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and airspeeds. The effect of approach flight path guidance on approach noise levels was also explored in the test series using minimal guidance and in others with both verbal and visual guidance. Helicopter cockpit data were recorded using a video recorder. A measurement technique capable of quantifying the wind micro-structure was employed to obtain insight into possible effects resulting from wind gradients and turbulence. Tracking data were acquired for comparison purposes using three independent techniques, 1) radar, 2) laser, and 3) photo-scaling.

- g) Preliminary results indicate day-to-day or pilot-to-pilot differences generally less than 0.6 dB, however, two test series resulted in greater differences. The degree of flight path guidance also appears to have a negligible effect on noise levels for the Bell 206L-1. Internal consistency was clearly evident in comparing the four repeats of the ICAO core operations. PNLTM data plotted against advancing blade tip Mach number support the concept of separate source-noise correction functions for each of the three certification microphone locations.

1.2.2.2.3 Findings and conclusions

- a) As had been anticipated, the HNMRP tests yielded considerable insight into areas of Chapter 8, Annex 16, which could be modified for improvement (i.e., for improvements in testing consistency or in ease of testing). These areas resulted in two categories. First, observations that were identified in advance of complete data reduction and analysis and, secondly, observations resulting from the synthesis of the data and the detailed analysis of the final data results.
- b) To clarify the definition of the reference take-off flight path presented in Chapter 8, Section 8.6.2.1 a) and 8.6.2.1 f) of Annex 16, it was agreed that the first segment level flight path and the second segment take-off climb should be represented as two straight lines intersecting 500 metres prior to the take-off measurement point. It was also noted that the best rate of climb (BRC) and V_y should be certificated values based on a minimum performance scenario (i.e., variable torque engine, hot-day cooling requirements, etc.). The recommended Annex change is shown in Attachment B, Section 8.6.2.1 a) and f).
- c) Related to the above discussion on the definition of the reference take-off flight path there was considerable discussion on the issue of minimizing the adjustments from the test take-off flight path. It was agreed that the existing Section 9.2.1 of Appendix 4 could be modified as shown in Attachment B and that

the magnitude of each of the component parts of the adjustments given in Section 8.7.5 should be specified. This is to be accomplished by limiting the A, correction, which is related to the test deviation from the reference flight path, to a value of 2.0 EPNdB. The recommended Annex changes are shown in Attachment B, Section 8.7.5 and Section 9.2.1.

- d) The issue of the appropriate flyover speed to be used in level flyover testing resurfaced during the helicopter noise repeatability test programme. Since V_{NE} may not relate to the level flight condition limit for all aircraft, it was suggested that the value of V_H , the maximum level flight speed associated with installed maximum engine power, or torque, or other continuous limit, should be used as a reference where V_{NE} does not first intervene. Difficulties were identified with the specific definition of V_H and regulatory language was suggested for the purpose of noise certification testing. The resulting Chapter 8 modifications and an additional Note are indicated in Attachment B, Chapter 8, Section 8.6.3.1 b).
- e) It was observed during the HNMRP testing that differences in the measured values on the order of 0.5 to 0.7 dB could result from differences in the response characteristics of the analysis system used. Since all of the analyzers used could meet the dynamic response characteristics in Annex 16, Appendix 4, Section 3.4, it was agreed by the group that the detector/integrator characteristics should be redefined to eliminate the source of variability. One member additionally suggested that the International Electrotechnical Commission (IEC) be asked to define these characteristics. A proposed rewording is indicated in Attachment B, which would alter the rising response characteristics and provide two falling response requirements.
- f) Early evaluation in the programme of the source noise adjustment indicated that the appropriate adjustment parameter should be **PNLTM**, which could be defined as a function of the advancing rotor-blade Mach number. The use of this sensitivity parameter would avoid possible confusion in adjustments related to duration effects. The Working Group agreed to recommend the revision presented in Appendix 4, Section 9.5 of Attachment B.
- g) Industry expressed the view that there may be a change in noise level stringency resulting from many of the proposed amendments. These stringency issues have yet to be assessed. Likewise, the resulting added complexity and certification costs have not been evaluated. The industry also expressed the view that the proposed changes be placed in the guidance section of Annex 16 to allow further study and assessment.

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the proposed Appendix 4, Part 9, amendment proposals indicated in Attachment B.

- e) For the overflight condition, there was still considerable debate on how to specify noise source correction requirements. It was acknowledged that further work was needed to explain or even to understand the variabilities in test results, and that the blade-tip Mach number vs. PNLTM values which were used in the repeatability tests may not even reflect the dominant noise source (in some cases it could be the tail rotor or engine noise, for example). With this factor in mind, the Committee agreed to new wording for Section 9.5 of Appendix 4, as indicated in Attachment B. However, the Committee stressed that, in adopting the wording of paragraph 9.5, as proposed by Working Group II and revised by the Committee during this meeting, it agrees that the subject of further research into the parameters influencing and varying helicopter noise during level overflight is an appropriate item for the future work programme of the CAEP.
- f) There was some discussion on reducing the acceptable noise levels for helicopters. Several members **favoured** such an action in the future, but without data on the resulting effects on cost and complexity, there was reluctance to change at this time. Consequently, the Committee elected to retain current noise level requirements.

1.2.2.3 Economic assessment of possible future standards

Further development of noise certification standards should be accomplished within the constraint of economic reasonableness. CAN/7 considered a methodology which was considered useful in assessing the operational cost of helicopter noise modifications. It was suggested that the economic methodology could be modified as necessary and updated to represent conditions in the 1985-1986 timeframe. The concept of helicopter productivity as used in CAN/7 and data from a recent trade publication, which had corresponding productivity factors, were disseminated to the group for evaluation. Analysis of the data indicated that major errors in the productivity factors could be introduced, depending on the interpretation of the economic methodologies guidelines. These errors resulted from the differences in designation of passengers and/or pilots, definitions of payload, and definition of the normal cruising speed of the helicopters. It is important that future methodologies used to assess economic reasonableness of noise-control features, be developed on a fair and consistent basis. It is, therefore, suggested that the methodology be updated for consistency in this area, as well as for other current economic factors. One member cautioned the Committee not to place too much emphasis on economic considerations, **but** to balance those with the environmental protection considerations. After noting the general agreement on this point the Committee agreed on the methodology modification in paragraph 1.2.2.3.2 below. It was

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TABLE 1.2

GUIDE FOR THE PRESENTATION OF HELICOPTER OPERATING COST ESTIMATESDIRECT OPERATING COST (Variable) \$ US

1. Fuel and Lubricants

Gross Weight 10% Less than Maximum Certified
 Cruising Speed 10% Less than VH for that Weight
 Altitude 1,000 Ft, ISA Day
 Fuel Cost \$1.90/Gal.
 Lubricants 2% of Engine Fuel

2. Direct Maintenance

a) Airframe

<u>Item</u>	<u>Parts Cost</u>	<u>Labor Cost*</u>
Inspection	Manufacturers Price Estimate	Manhours (MH) per flight hour based on manufacturers data
Overhaul	Project Parts Cost of Component Divided by Expected Actual TBO's	MH/FH - manufacturers data from operator surveys
Unscheduled/ on condition	Manufacturers Price Estimate	MH/FH - from operator surveys
Retirements	Prorated Price of Life-Limited Items	MH/FH - based on manufacturer replacement estimate divided by hours of life limit

b) Engines

1) Inspection	Based on Engine Manufacturers Price	MH/FH based on manufacturers data
Overhaul	Module and Exchange Cost Divided by Expected Actual TBO's	MH/FH - Engine manufacturers data
Unscheduled/ on condition	Line Maintenance Parts Price	MH/FH - From Operators Surveys

or

1i) Engine Manufacturer Supplied Exchange Price or Power-by-the-Hour
 (Whichever is Least Expensive)

*Direct Maintenance Labor Cost at \$35/hr

INDIRECT OPERATING COSTS (Fixed)

3. Crew Costs

\$35,000/Yr/Crew Member - No. Crew Specified by Manufacturer
 Light-600 Hr/Yr/Pilot
 Medium-800 Hr/Yr/Pilot
 Heavy-1200 Hr/Yr/Pilot

4. Insurance

8% of Flyaway Cost Per Year

5. Depreciation/Amortization of Investment

Depreciation is 10% Per Year of Initial Investment
 (Equivalent to Straight Line Over 10 Years to 0 Residual)

6. Interest

U.S. Prime Rate + 2pts. Applied to 80% of Flyaway Cost

7. Overhead

100% of Items 2a) and 2b) Labor and 3) Crew Costs/hr

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1.2.2.4 Noise abatement operating procedures

The subject of noise abatement operating procedures was raised during the CAN/7 meeting. Working Group II was subsequently directed to study and report on noise abatement operating procedures by the Terms of Reference, and consideration of noise-abatement operating procedures was retained as a part of the WG/II programme for helicopters. Two very extensive flight test programmes have been conducted by Working Group members with the objective of specifying noise abatement operational procedures which could improve the environmental acceptability of helicopters. The two programmes evolved in a different manner: one addressing primarily the detailed capabilities of noise control, which would be aircraft specific; and the other programme addressing more generalized procedures with the objective of presenting them as broad guidance material for controlling the helicopter noise. The group in any event had been apprised of the importance of developing such operational procedures in liaison with the ICAO Helicopter Operations Panel.

1.2.2.4.1 Aircraft specific operational procedures

- a) The French member provided the Working Group with results of an extensive noise-control operational procedures study conducted using a SA-365N Dauphin helicopter. The study was designed to explore the best operational technology available to reduce noise in the community resulting from helicopter flyovers, take-offs, or approaches. The programme was conducted in two phases, with the first phase addressing the use of operational procedures to minimize noise at the source and the second phase addressing operational procedures which would produce the "least noise" acoustic impact on the ground. The first phase addressed primarily the reduction of impulsive noise. The second phase produced "acoustic iso-level" contour curves from measurements recorded using a 24 microphone array.
- b) The flyover procedures consisted of stabilized overflight at a 300 metre altitude, using flight speeds varying over a range of approximately 70 knots and with two values of gross mass. The take-offs were conducted using three different procedures designed to rapidly increase the distance between the helicopter and the ground. The approach procedures were varied to avoid operation at the high impulsive conditions associated with blade-vortex interaction. The ICAO Annex 16, Chapter 8 procedures were followed in all operational modes. The "acoustic iso-levels", which were developed for take-offs followed by level flyovers and approach preceded by the 300-metre flyover, clearly identified the minimum-width noise-impact corridors for the Dauphin helicopter which are achievable with different operational procedures. From the study of the SA-365N helicopter noise-impact patterns, it was seen that bypassing quiet areas on

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1.2.2.4.3 Conclusions

The flight test programmes conducted by Working Group II members have provided valuable information on the specifics of noise abatement operational procedures. The data generated will be useful in planning operations in the vicinity of heliports. In fact, permission to operate aircraft into some heliports may be subject to noise restrictions. One way to accommodate these restrictions would be through identification of noise abatement operational procedures and resulting noise levels in the aircraft operational manual. In view of the highly aircraft-specific nature of noise abatement operational procedures and of the early stages of development of these procedures, it was agreed that it would be premature to recommend specific procedures. Although some members felt the Committee was ultimately responsible for developing helicopter noise abatement procedures, the majority concluded that the Committee could only advise on operational procedures. Further, the CAEP could certainly make specific procedural recommendations to the HELIOPS Panel. It was suggested and agreed that copies of this report, including information on the two operational procedure tests, would be made available to members of the HELIOPS Panel by the ICAO Secretariat. Future review of operational procedures, in co-ordination with the HELIOPS Panel, may be considered a potential area for further work in helicopter environmental noise control.

1.2.3 Special issue

1.2.3.1 A special issue considered by the Working Group dealt with the applicability statement in Section 8.1.1 of Chapter 8 dealing with the exceptions noted for agricultural, fire fighting, or external load carrying helicopters. The group noted that the CAN/7 recommendation which included the phrase "... except those designed exclusively for . . ." had been editorially changed to read "The Standards of this chapter shall apply to all helicopters except those specifically designed for agricultural fire fighting, or external load carrying purposes ." The group believed that the revised wording could lead to questionable exceptions based on inappropriate interpretation of the words "... specifically designed for . . .". Accordingly, the group decided to reintroduce the CAN/7 proposed wording which is indicated in Attachment B.

1.2.3.2 There was considerable discussion during CAEP/1 on the appropriate wording for 8.1.1b). A proposal had been made to change the word "significant" to "adverse" which would then mean that derived versions of an existing helicopter would not have to have a new noise certification unless they were noisier than the original version. Some members felt that this left a loophole allowing an endless stream of derivatives which would never be noise

associated with typical helicopter operations; however, it was again noted that many of the noise controlled operations were effective on an aircraft-specific basis. The data acquired will be useful in providing guidance in the development of helicopter operational noise control procedures and will be useful in the environmental planning for future heliport designs.

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The flight test programmes conducted by Working Group II members have provided valuable information on the specifics of noise abatement operational procedures. The data generated will be useful in planning operations in the vicinity of heliports. In fact, permission to operate aircraft into some heliports may be subject to noise restrictions. One way to accommodate these restrictions would be through identification of noise abatement operational procedures and resulting noise levels in the aircraft operational manual. In view of the highly aircraft-specific nature of noise abatement operational procedures and of the early stages of development of these procedures, it was agreed that it would be premature to recommend specific procedures. Although some members felt the Committee was ultimately responsible for developing helicopter noise abatement procedures, the majority concluded that the Committee could only advise on operational procedures. Further, the CAEP could certainly make specific procedural recommendations to the HELIOPS Panel. It was suggested and agreed that copies of this report, including information on the two operational procedure tests, would be made available to members of the HELIOPS Panel by the ICAO Secretariat. Future review of operational procedures, in co-ordination with the HELIOPS Panel, may be considered a potential area for further work in helicopter environmental noise control.

1.2.3 Special issue

1.2.3.1 A special issue considered by the Working Group dealt with the applicability statement in Section 8.1.1 of Chapter 8 dealing with the exceptions noted for agricultural, fire fighting, or external load carrying helicopters. The group noted that the CAN/7 recommendation which included the phrase "... except those designed exclusively for . . ." had been editorially changed to read "The Standards of this chapter shall apply to all helicopters except those specifically designed for agricultural fire fighting, or external load carrying purposes ." The group believed that the revised wording could lead to questionable exceptions based on inappropriate interpretation of the words "... specifically designed for . . .". Accordingly, the group decided to reintroduce the CAN/7 proposed wording which is indicated in Attachment B.

1.2.3.2 There was considerable discussion during CAEP/1 on the appropriate wording for 8.1.1b). A proposal had been made to change the word "significant" to "adverse" which would then mean that derived versions of an existing helicopter would not have to have a new noise certification unless they were noisier than the original version. Some members felt that this left a loophole allowing an endless stream of derivatives which would never be noise

- e) completion of a study of the issues of speed control on approach;
- f) study of the need for continuous tracking during testing;
- g) investigation into the subject of parameters influencing and varying helicopter noise during level overflights; and
- h) consideration to developing a simplified certification scheme for light helicopters in the light of the higher relative cost of helicopter noise certification.

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- h) consideration to developing a simplified certification scheme for light helicopters in the light of the higher relative cost of helicopter noise certification.

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2.3 Approach reference procedure

The approach reference procedure shall be established as follows:

- a) the helicopter shall be stabilized and following approach paths of 3°, 6°, and 9°;
- b) the approach shall be made at a stabilized airspeed equal to the best rate of climb speed V_y , or the lowest approved speed for the approach, whichever is the greater, with power stabilized during the approach and over the flight path reference point, and continued to a normal touchdown;
- c) the approach shall be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, shall be maintained throughout the approach reference procedure; and
- e) the mass of the helicopter at touchdown shall be the maximum landing mass at which noise certification is requested."

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- c) the approach shall be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, shall be maintained throughout the approach reference procedure; and
- e) the mass of the helicopter at touchdown shall be the maximum landing mass at which noise certification is requested."

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Relevant existing text of Annex 16, Volume I	Proposed amendment
<p>8.7 Test procedures</p> <p>.</p>	
<p>8.7.5 Adjustments for differences between test and reference flight procedures shall not exceed 4.0 EPNdB on take-off or 2.0 EPNdB on overflight or approach.</p>	<p>8.7.5 Adjustments for differences between test and reference flight procedures shall not exceed:</p> <p>a) for take-off 4.0 EPNdB, of which the arithmetic sum of A1 and the term $-7.5 \log (QK/QrKr)$ from $\Delta 2$ shall not in total exceed 2.0 EPNdB;</p> <p>b) for overflight or approach 2.0 EPNdB.</p>
<p>8.7.6 Adjustments for differences between test and reference noise measurement positions shall be included with the flight procedure adjustments of 8.7.5 and limited accordingly.</p>	<p>8.7.6 During the test the average rotor rpm shall not vary from the normal maximum operating rpm by more than ± 1.0 per cent during the 10 dB-down time period.</p>
<p>8.7.7 The helicopter airspeed shall not vary from the reference airspeed appropriate to the flight demonstration by more than ± 9 km/h (5 kt) throughout the 10 db-down time period.</p>	<p>8.7.8 The helicopter shall fly within $\pm 10^\circ$ from the vertical above the reference track through the centre reference noise measurement position throughout the 10 db-down time period.</p>
<p>.</p>	<p>8.7.9 During the approach noise demonstration the helicopter shall be stabilized and following a steady glide slope angle of $6^\circ \pm 0.5^\circ$.</p> <p>8.7.10 Tests shall be conducted at a helicopter mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at a mass not exceeding 105 per cent of the relevant maximum certificated mass.</p>

Relevant existing text of Annex 16, Volume I	Proposed amendment
APPENDIX 4.- EVALUATION METHOD FOR NOISE CERTIFICATION OF HELICOPTERS 3.4 Analysis system	
3.4.1 The requirements relating to the analysis system are those of Appendix 2, 3.4. X	except for the response characteristics which are defined in Appendix 4, 3.4.2.
	3.4.2 For each detector/integrator, the response to a sudden onset or interruption of a constant sinusoidal signal at the respective 1/3-octave band centre frequency shall be measured at sampling instants 0.5 s, 1 s, 1.5 s and 2.0 s after the onset and 0.5 s and 1.0 s after interruption. The rising response at 0.5 s shall be -4 ±1 dB, and at 1 s -1.75 ±0.5 dB, at 1.5 s -1.0 ±0.5 dB, and at 2 s -0.5 ±0.25, relative to the 'steady-state level. The falling response shall be such that the sum of the decibel readings (below initial steady-state level) and the corresponding rising response reading is 6.5 ±1 dB, at both 0.5 s and 1 s and on subsequent records the sum of the onset plus decay must be greater than 7.5 decibels.
	<u>Note 1.</u> - For analyzers with linear detection an approximation of this response would be given by: Weighting Coefficients for Simulation of SLOW Response Current (Li) ½ s record: 33% Previous (Li-1) ½ s record: 24% Second (Li-2) ½ s record: 21% Third (Li-3) ½ s record: 17%

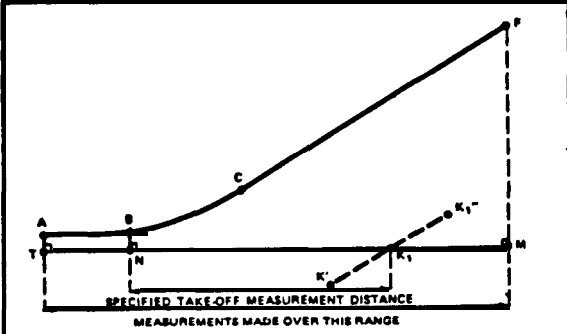
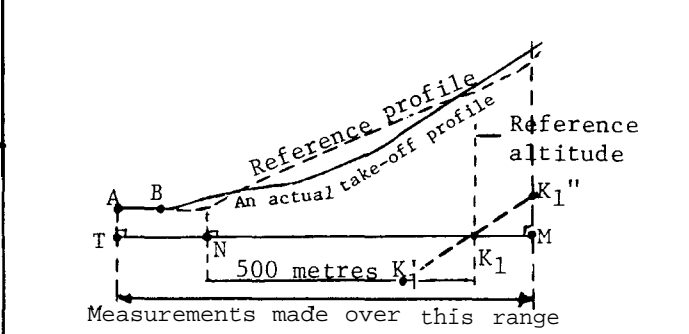
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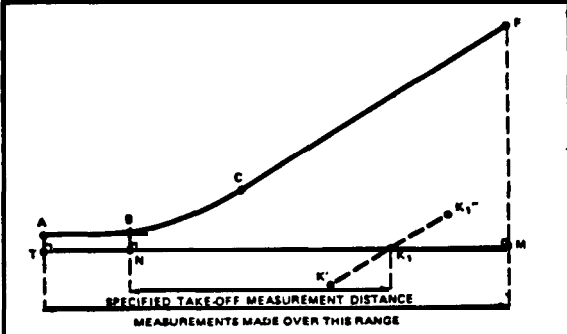
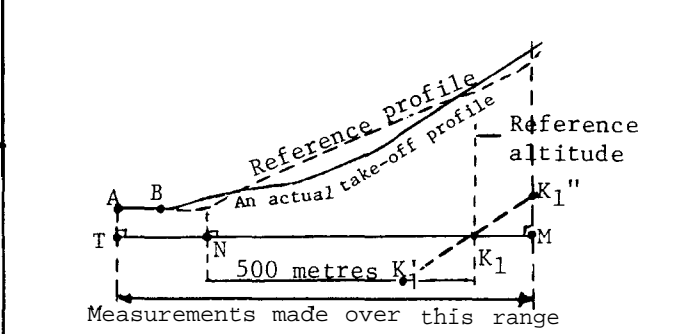
Relevant existing text of Annex 16, Volume I	Proposed amendment
<p>9. ADJUSTMENTS TO FLIGHT TEST RESULTS</p> <p>9.1 General</p>	
<p>9.1.1 Adjustments from test to reference conditions need not be made if the following test conditions are complied with:</p> <p>a) the helicopter shall fly within ± 10 m (33 ft) vertically and ± 10 from the zenith of the reference flight track throughout the 10 dB-down time period;</p> <p>b) the helicopter airspeed shall not vary from the reference airspeed appropriate to the flight demonstration (e.g. V_y, $0.9V_H$) by more than ± 9 km (± 5 kt) throughout the 10 dB-down time period. As far as overflight is concerned, the average difference between test airspeed and reference airspeed (see Chapter 8, 8.6.3.1) shall not exceed 4 km/h (2.2 kt);</p> <p>c) test shall be conducted at mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at mass not exceeding 105 per cent of the relevant maximum certificated mass;</p>	<div style="border: 1px solid black; padding: 2px; width: fit-content;">delete</div>

Relevant existing text of Annex 16, Volume I	Proposed amendment
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Relevant existing text of Annex 16, Volume I	Proposed amendment
<p>b) sound attenuation in air;</p> <p>c) parameters affecting noise generating mechanisms (e.g. rotor rpm, helicopter airspeed).</p>	<p>b) in the overflight case, parameters affecting the noise generating mechanisms such as those described in Section 9.5.</p>
<p>9.1.3 Where adjustments to the measured noise data are made, they shall be made using the methods prescribed in 9.3 and 9.4, for differences in the following:</p> <p>a) attenuation of the noise along its path as affected by "inverse square" and atmospheric attenuation:</p> <p>b) duration of the noise as affected by distance and speed of aircraft relative to the flight path reference point.</p>	<p>9.1.2 Adjustments to the measured noise data</p> <p>c) the adjustment procedure described in this Section shall apply to the side-line microphones in the take-off, overflight, and approach cases. Although the noise emission is strongly dependent on the directivity pattern, variable from one helicopter type to another, the propagation angle θ, defined in Appendix 2, 9.3.2, Figure 2.10, shall be the same for the test and reference flight paths. The elevation angle ψ shall not be constrained as in the third note of Appendix 2, 9.3.2, but must be determined and reported. The certification authority shall specify the acceptable limitations on ψ. Corrections to data obtained when these limits are exceeded shall be applied using procedures approved by the certificating authority.</p>

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Relevant existing text of Annex 16, Volume I	Proposed amendment
<p>a) The helicopter is initially stabilized in level flight at the best rate of climb speed, V_y, at point A and continues to point B where take-off power is selected and a steady climb initiated. A steady climb condition is achieved at point C and continued to point F, the end of the noise certification take-off flight path.</p> <p>.</p> <p>c) The distance TM is the distance over which the helicopter position is measured and synchronized with the noise measurements (see 2.3.2 of this Appendix).</p> <p>X</p>	<p>a) during actual testing the helicopter is initially stabilized in level flight at the best rate of climb speed, V_y, at a point A and continues to a point B where take-off power is applied and a steady climb is initiated. A steady climb shall be maintained throughout the 10 dB-down period and beyond to the end of the certification flight path (point F).</p> <p>Note. - The position of point B may vary within the limits allowed by the certificating authorities.</p>
 <p>FIGURE 4-1.- TYPICAL TAKE-OFF PROFILE</p>	 <p>FIGURE 4-1. TYPICAL TEST AND REFERENCE PROFILE;</p>

Relevant existing text of Annex 16, Volume I	Proposed amendment
<p>a) The helicopter is initially stabilized in level flight at the best rate of climb speed, V_y, at point A and continues to point B where take-off power is selected and a steady climb initiated. A steady climb condition is achieved at point C and continued to point F, the end of the noise certification take-off flight path.</p> <p>.</p> <p>c) The distance TM is the distance over which the helicopter position is measured and synchronized with the noise measurements (see 2.3.2 of this Appendix).</p> <p>X</p>	<p>a) during actual testing the helicopter is initially stabilized in level flight at the best rate of climb speed, V_y, at a point A and continues to a point B where take-off power is applied and a steady climb is initiated. A steady climb shall be maintained throughout the 10 dB-down period and beyond to the end of the certification flight path (point F).</p> <p>Note. - The position of point B may vary within the limits allowed by the certificating authorities.</p>
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Relevant existing text of Annex 16, Volume I	Proposed amendment
	<p><u>Note 2.</u>— When using advancing blade tip Mach number it should be computed using true airspeed, on-board outside air temperature (OAT), and rotor speed.</p>

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Agenda Item 2: Noise certification of propeller-driven aeroplanes

Further development of proposed new Chapter "X" and the associated Appendix "X" for possible application to future light propeller-driven aeroplanes.

2.1 Light propeller-driven aeroplanes2.1.1 Introduction

2.1.1.1 It was noted that noise standards for light propeller-driven aeroplanes (LPDA) are at present contained in Chapter 6 of Annex 16, Volume I. However, at the Seventh Meeting of the Committee on Aircraft Noise (CAN/7) held in 1983, it was recommended (Recommendation 2/2) that a trial application should be made by manufacturing States of a proposed new Chapter X (with associated Appendix) for Annex 16, Volume I for the noise certification of LPDA. The new Chapter X differed from Chapter 6 mainly in requiring noise measurements to be made during a climb-out procedure, rather than during an overflight procedure, and in specifying more corrections to the measured noise for deviations from the standard test conditions. At the time of CAN/7, it had not been possible to set proposed noise limits for use in Chapter X.

2.1.1.2 CAN/7 established a working group (WG/II) to undertake further work on the noise certification of LPDA which included a number of topics directly related to the proposed new Chapter X of Annex 16, Volume I. When the Committee on Aircraft Noise was subsequently disbanded and CAEP was established; the same work was transferred to WG/II of CAEP.

2.1.1.3 Working Group II, which included almost all members of the Committee or their representatives held four meetings (in Amsterdam, Boston, Tokyo and Ottawa) and held extensive discussions on all aspects of the proposed new Chapter X. The meeting discussed the report of WG/II as well as individual working papers on issues raised by the report and related matters as indicated below.

2.1.2 Retention of Chapter 6

An observer questioned the desirability of introducing the new Chapter X since comparison between aeroplanes certificated to Chapter 6 and to Chapter X would be difficult. Furthermore, under Chapter X high performance aeroplanes which might be very noisy during the take-off run would be able to climb rapidly to reach a high altitude over the measuring point, thereby satisfying the certification requirements. It was however pointed out that it was one of the objectives of Chapter X to be more representative of real-life situations such as that described where credit was obtained for better performance .

2.1.3 Flight test data

As recommended at CAN/7 a considerable amount of flight testing in accordance with Chapter X had been carried out and a significant data base had been built up. Wind tunnel tests had also been carried out with a view to determining the correlation between noise measurements made during flyover in accordance with Chapter 6 and during climb-out in accordance with Chapter X. These tests, which had been complemented by flight tests, had shown the important acoustic effect of non-normal airflow into the plane of the propeller.

2.1.4 Miscellaneous matters relating to test and analysis

The Working Group made recommendations relating to a number of different aspects of the Chapter X test and analysis procedures which were accepted by the meeting. These were as follows:

- a) The flight tests had revealed that some data might be unreliable because of inaccuracies in some mechanical tachometers. A provision which specified the tachometer accuracy required during flight testing was therefore developed for inclusion in Chapter X;
- b) a revised correction for non-reference atmospheric absorption when test conditions were outside the reference "window" conditions of temperature and humidity was developed. This was necessary because of the change of reference temperature from 25°C to 15°C;
- c) editorial changes were made and a clarifying note was added to the specification for the power to be used during the second phase take-off reference procedure;
- d) due to the sensitivity of noise measurements to the air in-flow angle to the propeller plane mentioned in 2.1.3 above it was considered that some control was needed on the mass of the aeroplane during flight test since this would affect the angle of attack. Limits were likewise placed on variation of the aeroplane speed at which the climb-out tests should be conducted; and
- e) to reduce the complexity and cost of testing it was proposed that the necessary test meteorological measurements could be made 1.2 metres above the ground rather than 10 metres.

2.1.5 Adjustment of test results

2.1.5.1 It was noted that the Working Group was suggesting changes to the Chapter X procedures for adjusting measured noise levels for variations in propeller helical tip Mach No. and for engine noise. These changes were based upon data obtained during the wind tunnel and flight test programme mentioned in 2.1.3 above.

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years from the date of implementation of Chapter X, a 1.2-metre microphone should be used in parallel with a ground microphone for certification, with both microphones corrected to remove any spectral distortions which could arise from ground reflections. During this period, the measurements with the 1.2-metre microphone would be used to determine compliance with the standard, while the simultaneous measurements taken with the ground microphone would be used to extend the data base, enabling a reassessment of the Chapter X limits to be undertaken at the end of the period. The Working Group also considered that some explanation should be given in the Annex of the reasons for requiring simultaneous measurements with microphones in both positions. It had consequently developed draft texts of two alternative explanatory Notes for inclusion in the Annex for further consideration by CAEP/1.

2.1.6.4 The meeting was advised of work that had been carried out in one State since the conclusion of the Working Group mentioned above had been reached. It was suggested that if the results of this work had been available to the Working Group, its conclusions might have been different. As a result of this work, it was proposed that Chapter X should require the use of the ground-plane microphone only and that reference to the 1.2-metre microphone should be deleted. Furthermore, it was proposed that the pressure-doubled noise levels measured by the ground-plane microphone should be corrected to free field values for comparison with the certification limits. This proposal was made because the studies had indicated the serious difficulties which arose in attempting to correct measurements made with a 1.2-metre microphone for ground reflection effects which were considered too complex and therefore unsuitable for the regulatory purpose intended. Among the factors which had been shown to affect the 1.2-metre microphone measurements were:

- a) the exact height of the microphone above the noise reflecting surface;
- b) the spectral distribution of the noise;
- c) temperature; and
- d) any deviation of the test flight path of the aeroplane from the reference flight path.

Note.— The term "free field" is used to represent the sound level that would be recorded if there were no acoustically reflecting surfaces in the test area and the term "pressure-doubled" implies total reinforcement of the sound level by a large reflecting surface.

To overcome these correction difficulties, it was suggested that the better solution would be to use only the ground-plane microphone and adjust the noise limits to maintain the same stringency.

2.1.6.5 In opposition to this proposal, it was pointed out that the large data base which had been accumulated and on which the selection of limits would have to be based had been collected with a 1.2-metre microphone and a less extensive data base existed for a ground-plane microphone. Furthermore, it was not accepted, on the basis of test evidence, that a simple and acceptably accurate correction procedure for ground reflection effects for the 1.2-metre microphone could not be devised. It was moreover felt to be an important principle that the test procedures used should be perceived to have some relationship to the position of an observer who might hear the noise in natural surroundings, and a ground-plane microphone did not meet this criterion. It was recalled that the take-off test procedure of Chapter X had been introduced for this very reason. It was also mentioned that if a ground-plane microphone were used, with corrections to free field conditions, changes to the limits would be necessary to ensure equivalent stringency and these might be difficult to explain to a non-technical person who was interested primarily in the environmental impact of the certification scheme. Taking all these points into account, it was considered that it would be much preferable to retain the dual measurement proposal made by the Working Group.

2.1.6.6 A number of members expressed the view that the ground-plane microphone showed a clear technical superiority to the 1.2-metre microphone, but were concerned at the lack of a data base for the former installation. It was also suggested that differences between the objectives of a certification procedure and an airport monitoring procedure should not be difficult to explain and should not be allowed to prejudice the use of the best technical solution. The point was also made that once a choice had been made, and the procedure had been in use for a number of years, it would be difficult to change it, even if the data collected showed another system to be superior. It was therefore essential to select the best possible solution from the outset. While some members considered that the CAEP was a technical body and should only take account of technical arguments others felt that the possible public perception aspect should be given as much weight as the purely technical ones.

2.1.6.7 The meeting was advised that the proposal made by the Working Group, which required dual measurement, was not appropriate in the form suggested for inclusion in an ICAO Annex. A similar objective could however be achieved by specifying only one microphone position in the Annex and adding a recommendation in the report that States be asked to carry out dual measurements for the purpose of accumulating a data base.

2.1.6.8 A possible compromise between the opposing views described above was suggested which would involve simultaneous measurement by microphones in both positions with the difference in readings obtained from the two microphones being used to correct the 1.2-metre microphone reading to a value not affected by ground reflection interference. Some members opposed this suggestion on the grounds that the 1.2-metre microphone readings would still be subject to the inaccuracies previously mentioned. It would moreover be difficult to explain to a non-technical enquirer. This proposal was eventually withdrawn.

2.1.6.5 In opposition to this proposal, it was pointed out that the large data base which had been accumulated and on which the selection of limits would have to be based had been collected with a 1.2-metre microphone and a less extensive data base existed for a ground-plane microphone. Furthermore, it was not accepted, on the basis of test evidence, that a simple and acceptably accurate correction procedure for ground reflection effects for the 1.2-metre microphone could not be devised. It was moreover felt to be an important principle that the test procedures used should be perceived to have some relationship to the position of an observer who might hear the noise in natural surroundings, and a ground-plane microphone did not meet this criterion. It was recalled that the take-off test procedure of Chapter X had been introduced for this very reason. It was also mentioned that if a ground-plane microphone were used, with corrections to free field conditions, changes to the limits would be necessary to ensure equivalent stringency and these might be difficult to explain to a non-technical person who was interested primarily in the environmental impact of the certification scheme. Taking all these points into account, it was considered that it would be much preferable to retain the dual measurement proposal made by the Working Group.

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2.1.6.7 The meeting was advised that the proposal made by the Working Group, which required dual measurement, was not appropriate in the form suggested for inclusion in an ICAO Annex. A similar objective could however be achieved by specifying only one microphone position in the Annex and adding a recommendation in the report that States be asked to carry out dual measurements for the purpose of accumulating a data base.

2.1.6.8 A possible compromise between the opposing views described above was suggested which would involve simultaneous measurement by microphones in both positions with the difference in readings obtained from the two microphones being used to correct the 1.2-metre microphone reading to a value not affected by ground reflection interference. Some members opposed this suggestion on the grounds that the 1.2-metre microphone readings would still be subject to the inaccuracies previously mentioned. It would moreover be difficult to explain to a non-technical enquirer. This proposal was eventually withdrawn.

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period, aeroplanes which could not meet the requirements to satisfy instead the existing Chapter 6 requirements (see 2.1.10 of this part of the report) and that this should allow stringency to be increased.

2.1.8.3.2 After a careful consideration of the arguments, the meeting decided that stringency should not be increased at present. It was however noted that the levels of stringency of all the provisions in Annex 16 were kept under review by the Committee as a matter of course and could be revised in the future. Three members wished to record their disappointment that there had been no increase in stringency.

2.1.8.3.3 The proposal referred to in 2.1.8.1.2 above was reviewed in light of the subsequent decisions on reference level and stringency. It was agreed that, as presented, they did not represent measurable values which could be identified as an equivalent level of stringency to the Chapter 6 requirements and they were adjusted accordingly.

2.1.9 Applicability to derived versions

It was noted that the Working Group had recommended that the Chapter X provisions be made applicable to all derived versions so that all such aeroplanes would be certificated to Chapter X requirements as soon as possible. It was further noted that this recommendation was based on the assumption that the definition of a derived version in Part I would be amended. Amendments to the definition were consequently agreed. (For a discussion of the amendment to the definition, see 3.2.9 in the report of Agenda Item 3.)

2.1.10 Fallback provision

Because of the lack of flexibility in the Chapter X requirements (due to an absence of trade-off provisions) the Working Group had suggested the introduction of a provision which would allow applicants not able to meet the Chapter X requirements to make application under Chapter 6 instead. This provision would only be permitted for the first five years of the applicability of Chapter X. This proposal was agreed by the meeting.

2.1.11 Recommendation

In light of the preceding discussions, the meeting developed the following recommendations:

RSPP | RECOMMENDATION 2/1 - AMENDMENT TO ANNEX 16, VOLUME I - PROPELLER-DRIVEN AEROPLANES

That:

- a) Part I of Annex 16, Volume I be amended as indicated in Attachment A to this part of the report.

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ATTACHMENT A TO THE REPORT ON AGENDA ITEM 2PROPOSED AMENDMENT TO PART I OF ANNEX 16, VOLUME I

Relevant existing text of Annex 16, Volume I	Proposed amendment
PART I. DEFINITIONS Derived version of an aircraft. An aircraft which, from the point of view of airworthiness, is similar to the noise certificated prototype but incorporates changes in type design which may affect its noise characteristics. X	
	adversely
Note X.- Where the certificating authority finds that the proposed change in design, configuration, power or mass is so extensive that a substantially new investigation of compliance with the applicable airworthiness regulations is required, the aircraft should be considered to be a new type design rather than a derived version.	1
X	Note 2.- Where more than one measurement point is involved, adversely shall refer to the nett change in noise levels.

- - - - -

Relevant existing text of Annex 16, Volume I	Proposed amendment
<p>6.3 Maximum noise levels</p> <p>6.3.1 For aeroplanes specified in 6.1.1 a) and 6.1.1 b), the maximum noise levels when determined in accordance with the noise evaluation method of Appendix 3 shall not exceed the following:</p> <ul style="list-style-type: none"> - a 68 dB(A) constant limit up to an aeroplane mass of 600 kg, varying linearly with mass from that point to 1 500 kg, after which the limit is constant at 80 dB(A) up to 5 700 kg <p>(except that in the case of an application for a change in type design, the maximum certificated take-off mass may not exceed 6 500 kg, provided that the prototype has been certificated at a maximum certificated take-off mass not exceeding 5 700 kg) .</p> <p>.</p> <p><u>APPENDIX 3</u></p> <p><u>NOISE EVALUATION METHOD FOR NOISE CERTIFICATION OF PROPELLER-DRIVEN AEROPLANES NOT EXCEEDING 5 700 kg</u></p>	<p>9 000</p> <p>delete</p> <p>9 000</p>

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- A 76 dB(A) constant limit up to an aeroplane mass of 600 kg varying linearly from that point with the logarithm of aeroplane mass at the rate of 9.83 dB(A) per doubling of mass until the limit of 88 dB(A) is reached after which the limit is constant up to 9 000 kg.

X.5 Noise certification reference procedures

X.5.1 General conditions

X.5.1.1 The calculations of reference procedures and flight paths shall be approved by the certificating authorities.

X.5.1.2 Except in conditions specified in X.5.1.3, the take-off reference procedure shall be that defined in X.5.2.

X.5.1.3 When it is shown by the applicant that the design characteristics of the aeroplane would prevent flights being conducted in accordance with X.5.2, the reference procedures shall:

a> depart from the reference procedures defined only to the extent demanded by those design characteristics which make compliance with the procedures impossible; and

b) be approved by the certificating authorities.

X.5.1.4 The reference procedures shall be calculated under the following atmospheric conditions:

a) sea level atmospheric pressure of 1 013.25 hPa;

b) ambient air temperature of 15°C, i.e., ISA;

c) relative humidity of 70 per cent; and

d) zero wind.

X.5.1.5 The acoustic reference atmospheric conditions shall be the same as the reference atmospheric conditions for flight.

X.5.2 Take-off reference procedure

The take-off flight path shall be calculated taking into account the following two phases.

- A 76 dB(A) constant limit up to an aeroplane mass of 600 kg varying linearly from that point with the logarithm of aeroplane mass at the rate of 9.83 dB(A) per doubling of mass until the limit of 88 dB(A) is reached after which the limit is constant up to 9 000 kg.

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X.5.2 Take-off reference procedure

The take-off flight path shall be calculated taking into account the following two phases.

X.6.2 The test procedures and noise measurements shall be conducted and processed in an approved manner to yield the noise evaluation measure in units of L_{AMAX} as described in Appendix X.

X.6.3 Acoustic data shall be adjusted by the methods outlined in Appendix X to the reference conditions specified in this chapter.

X.6.4 If equivalent test procedures are used the test procedures and all methods for correcting the results to the reference procedures shall be approved by the certificating authorities.

Note.- Guidance material on the use of equivalent procedures is provided in the ICAO Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft (Doc ----).

APPENDIX X TO ANNEX 16, VOLUME 1

NOISE EVALUATION METHOD FOR NOISE CERTIFICATION OF PROPELLER-DRIVEN AEROPLANES NOT EXCEEDING 9 000 kg

(Note.- See Chapter X)

1. Introduction

Note 1.- This noise evaluation method includes:

- a) noise certification test and measurement conditions;
- b) noise unit;
- c) measurement of aeroplane noise received on the ground;
- d) adjustments to test data; and
- e) reporting of data to the certificating authorities and validity of results .

Note 2.- The instructions and procedures given in the method are clearly delineated to ensure uniformity during compliance tests and to permit comparison between tests of various types of aeroplanes, conducted in various geographical locations. The method applies only to aeroplanes within the applicability clauses of Part II, Chapter X.

2. Noise certification test and measurement conditions

2.1 General

This section prescribes the conditions under which noise certification tests shall be conducted and the measurement procedures that shall be used to measure the noise made by the aeroplane for which the test is conducted.

X.6.2 The test procedures and noise measurements shall be conducted and processed in an approved manner to yield the noise evaluation measure in units of L_{AMAX} as described in Appendix X.

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2.3.5 The aeroplane height when directly over the microphone shall be measured by an approved technique. The aircraft shall pass over the microphone within ± 10 degrees from the vertical and within 20 per cent of the reference height.

2.3.6 Aeroplane speed, position and performance data required to make the adjustments referred to in paragraph 5 of this Appendix shall be recorded when the aeroplane is directly over the measurement site. Measuring equipment shall be approved by the certificating authorities.

2.3.7 An independent device accurate to within ± 1 per cent, shall be used for the measurement of propeller rotational speed to avoid orientation and installation errors when the test aeroplane is equipped with mechanical tachometers.

3. Noise unit definition

The L_{AMAX} is defined as the maximum level, in decibels, of the A-weighted sound pressure (slow response) with reference to the square of the standard reference sound pressure (P_0) of 20 micropascals (μPa).

4. Measurement of aeroplane noise received on the ground

4.1 General

4.1.1 All measuring equipment shall be approved by the certificating authorities.

4.1.2 Sound pressure level data for noise evaluation purposes shall be obtained with acoustical equipment and measurement practices that conform to the specifications given hereunder in 4.2.

4.2 Measurement system

The acoustical measurement system shall consist of approved equipment equivalent to the following:

- a) a microphone system with frequency response compatible with measurement and analysis system accuracy as stated in 4.3;
- b) tripods or similar microphone mountings that minimize interference with the sound being measured;
- c) recording and reproducing equipment characteristics, frequency response, and dynamic range compatible with the response and accuracy requirements of 4.3; and
- d) acoustic calibrators using sine wave or broadband noise of known sound pressure level. If broadband noise is used, the signal shall be described in terms of its average and maximum root-mean-square (rms) value for non-overload signal level.

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with no cavities below the plate. The microphone shall be located three-quarters of the distance from the centre to the edge along a radius normal to the line of flight of the test aeroplane.

4.4.2 If the noise signal is tape-recorded, the frequency response of the electrical system shall be determined, during each test series, at a level within 10 dB of the full-scale reading used during the tests, utilizing pink or pseudorandom noise. The output of the noise generator shall have been checked by an approved Standards laboratory within six months of the test series, and tolerable changes in the relative output at each one-third octave band shall be not more than 0.2 dB. Sufficient determinations shall be made to ensure that the overall calibration of the system is known for each test.

4.4.3 Where a magnetic tape recorder forms part of the measuring chain, each reel of magnetic tape shall carry 30 seconds of this electrical calibration signal at its beginning and end for this purpose. In addition, data obtained from tape-recorded signals shall be accepted as reliable only if the level difference in the 10 kHz one-third octave band filtered levels of the two signals is not more than 0.75 dB.

4.4.4 The ambient noise, including both acoustical background and electrical noise of the measurement systems, shall be determined in the test area with the system gain set at levels which will be used for aeroplane noise measurements. If aeroplane peak sound pressure levels do not exceed the background sound pressure levels by at least 10 dB(A), a take-off measurement point nearer to the start of roll shall be used and the results adjusted to the reference measurement point by an approved method.

5. Adjustment to test results

5.1 When certification test conditions differ from the reference conditions appropriate adjustments shall be made to the measured noise data by the methods of this section.

5.2 Corrections and adjustments

5.2.1 The adjustments take account of the effects of:

- a) differences in atmospheric absorption between meteorological test conditions and reference conditions;
- b) differences in the noise path length between the actual aeroplane flight path and the reference flight path;
- c) the change in the helical tip Mach number between test and reference conditions ; and
- d) the change in engine power between test and reference conditions.

5.2.2 The noise level under reference conditions $(L_{\text{AMAX}})_{\text{REF}}$ is obtained by adding increments for each of the above effects to the test day noise level $(L_{\text{AMAX}})_{\text{TEST}}$.

$$(L_{\text{AMAX}})_{\text{REF}} = (L_{\text{AMAX}})_{\text{TEST}} + \Delta(M) + \delta(1) + \Delta(2) + \Delta(3)$$

where $\Delta(M)$ is the adjustment for the change in atmospheric absorption between test and reference conditions

$\delta(1)$ is the adjustment for noise path lengths

$\Delta(2)$ is the adjustment for helical tip Mach number, and

$\Delta(3)$ is the adjustment for engine power.

- a) When the test conditions are within those specified in Figure 6-1, no adjustments for differences in atmospheric absorption need be applied, i.e. $\Delta(M) = 0$. If conditions are outside those specified in Figure 6-1 then adjustments must be applied by an approved procedure or by adding an increment $\Delta(M)$ to the test day noise levels where,

$$\Delta(M) = 0.01 (H_T^\alpha - 0.2 H_R)$$

and where H_T is the height in metres of the test aeroplane when directly over the noise measurement point, H_R is the reference height of the aeroplane above the noise measurement point, and α is the rate of absorption at 500 Hz specified in Tables 1-5 to 1-1 6 of Appendix 1.

- b) Measured noise levels should be adjusted to the height of the aeroplane over the noise measuring point on a reference day by algebraically adding an increment equal to $\Delta(1)$. When test day conditions are within those specified in Figure 6-1:

$$\delta(1) = 22 \log (H_T/H_R)$$

When test day conditions are outside those specified in Figure 6-1:

$$\delta(1) = 20 \log (H_T/H_R)$$

where H_T is the height of the aeroplane when directly over the noise measurement point and H_R is the reference height of the aeroplane over the measurement point.

- c) No adjustments for helical tip Mach number variations need be made if the propeller helical tip Mach number is:

1) at or below 0.70 and the test helical tip Mach number is within 0.014 of the reference helical tip Mach number;

2) above 0.70 and at or below 0.80 and the test helical tip Mach number is within 0.007 of the reference helical tip Mach number;

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2) above 0.70 and at or below 0.80 and the test helical tip Mach number is within 0.007 of the reference helical tip Mach number;

5.2.2 The noise level under reference conditions $(L_{\text{AMAX}})_{\text{REF}}$ is obtained by adding increments for each of the above effects to the test day noise level $(L_{\text{AMAX}})_{\text{TEST}}$.

$$(L_{\text{AMAX}})_{\text{REF}} = (L_{\text{AMAX}})_{\text{TEST}} + \Delta(M) + \delta(1) + \Delta(2) + \Delta(3)$$

where $\Delta(M)$ is the adjustment for the change in atmospheric absorption between test and reference conditions

$\delta(1)$ is the adjustment for noise path lengths

$\Delta(2)$ is the adjustment for helical tip Mach number, and

$\Delta(3)$ is the adjustment for engine power.

- a) When the test conditions are within those specified in Figure 6-1, no adjustments for differences in atmospheric absorption need be applied, i.e. $\Delta(M) = 0$. If conditions are outside those specified in Figure 6-1 then adjustments must be applied by an approved procedure or by adding an increment $\Delta(M)$ to the test day noise levels where,

$$\Delta(M) = 0.01 (H_T^\alpha - 0.2 H_R)$$

and where H_T is the height in metres of the test aeroplane when directly over the noise measurement point, H_R is the reference height of the aeroplane above the noise measurement point, and α is the rate of absorption at 500 Hz specified in Tables 1-5 to 1-1 6 of Appendix 1.

- b) Measured noise levels should be adjusted to the height of the aeroplane over the noise measuring point on a reference day by algebraically adding an increment equal to $\Delta(1)$. When test day conditions are within those specified in Figure 6-1:

$$\delta(1) = 22 \log (H_T/H_R)$$

When test day conditions are outside those specified in Figure 6-1:

$$\delta(1) = 20 \log (H_T/H_R)$$

where H_T is the height of the aeroplane when directly over the noise measurement point and H_R is the reference height of the aeroplane over the measurement point.

- c) No adjustments for helical tip Mach number variations need be made if the propeller helical tip Mach number is:

1) at or below 0.70 and the test helical tip Mach number is within 0.014 of the reference helical tip Mach number;

2) above 0.70 and at or below 0.80 and the test helical tip Mach number is within 0.007 of the reference helical tip Mach number;

6.1.4 Comments on local topography, ground cover and events that might interfere with sound recordings shall be reported.

6.1.5 The following aeroplane information shall be reported:

- a) type, model and serial numbers of aeroplane, engine(s) and propeller(s);
- b) any modifications or non-standard equipment likely to affect the noise characteristics of the aeroplane;
- c) maximum certificated take-off mass;
- d) for each overflight, airspeed and air temperature at the flyover altitude determined by properly calibrated instruments;
- e) for each overflight, engine performance as manifold pressure or power, propeller speed in revolutions per minute and other relevant parameters determined by properly calibrated instruments;
- f) aeroplane height above the measurement point;
- g) corresponding manufacturer's data for the reference conditions relevant to d), e) and f) above.

6.2 Validity of results

6.2.1 The measuring point shall be overflown at least six times. The test results shall produce an average noise level ($L_{A_{max}}$) value and its 90 per cent confidence limits, the noise level being the arithmetic average of the corrected acoustical measurements for all valid test runs over the measuring point.

6.2.2 The samples shall be large enough to establish statistically a 90 per cent confidence limit not exceeding ± 1.5 dB. No test results shall be omitted from the averaging process, unless otherwise specified by the certificating authorities.

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3.2 Discussion

3.2.1 General

The Committee expressed its deep appreciation to the members of the Working Group for their efforts and the excellent manner in which they had co-operated in the studies undertaken to progress work on the various tasks assigned to the group. The Committee was very pleased with the overall recommendations of the group and noted that these recommendations were satisfactorily backed by comprehensive information to enable it to decide on a further course of action on individual tasks. The Committee noted that it had been necessary for the Working Group to establish two subgroups to deal with residual technical problems and noise contour methodology. The Committee further noted that the Working Group had held three technical meetings during which 37 working papers and 9 information papers were considered. A fourth meeting of the group was held to approve the draft report for submission to the CAEP/1 meeting.

3.2.2 Changes in composition and noise status of world airline fleet

3.2.2.1 The Committee noted that the Working Group had, from its study, drawn the following conclusions:

- a) Since the final meeting of the Committee on Aircraft Noise (CAN/7), the proportion of non-noise-certificated aeroplanes in the world airline fleet has halved, from 41% to 20% while the proportion of Chapter 3 aeroplanes has more than doubled, from 11% to 26%. At the beginning of 1982 the ratio of Chapter 3 to Chapter 2 aeroplanes on order was 2.8:1 while at the end of 1985 it was 21:1. By projecting these trends it is likely that the proportion of Chapter 3 aeroplanes in the fleet will increase rapidly. (See Tables 3.1 to 3.3 giving composition and noise status of civil subsonic jet airline fleets in 1982 and 1985 and the differences during these periods.)
- b) Although CAN/7 agreed not to place any formal limitation on the production of Chapter 2 aeroplanes, such a limitation has effectively taken place so that Chapter 2 aeroplanes are now only being built in small numbers.

3.2.2.2 The Committee noted the above conclusions and considered the information in Tables 3.1 to 3.3 useful for inclusion in this report.

3.2.3 Advances in acoustic technology

3.2.3.1 The Committee noted that the Working Group, from its study, had concluded that:

- a) there were no developments which were likely to produce noise reductions of the order necessary to enable a worthwhile

reduction of the Chapter 3 noise levels at this time. For greater values of take-off mass in the region of 200-400 tons, it is likely that the needs of airlines will be met by derivatives of existing designs in view of the very substantial investment needed for entirely new types. These derivatives will depend heavily on existing airframe and engine technology and at present these do not offer prospects of noise reductions large enough to justify major revision of these Standards.

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**TABLE 3.3 DIFFERENCES IN COMPOSITION AND NOISE STATUS OF WORLD
SUBSONIC JET AEROPLANE FLEET BETWEEN 1982 AND 1985**
(See notes on Tables 2.1 and 2.2)

Category and Type	Changes in Number in Fleet	Changes in Noise Certification Status of Fleet		
		None	Chap 2	chap 3
<u>old Technology</u>				
Caravelle	- 21	- 20	1	0
Mercure	+ 1	0	+ 1	0
F28	+ 51	0	+ 51	0
VC10 & S VC10	- 14	- 14	0	0
Trident	- 48	- 48	0	0
Bae 111	- 43	- 100	+ 57	0
B707 and 720	- 293	- 317	+ 24	0
B727-100	- 21	- 133	+ 112	0
B727-200	+ 35	- 29	+ 64	0
B737 (Except-300)	+ 312	6	+ 318	0
DC8 (Except-70)	- 82	- 95	+ 13	0
DC9 (Except-80)	+ 8	- 315	+ 323	0
CV 880/990	- 57	- 57	0	0
SUB TOTAL	- 172	- 1134	+ 962	0
<u>Current Technology</u>				
A300	+ 82	0	0	+ 82
B747	+ 87	0	- 186	+ 273
DC10-10, 15, 40	+ 5	0	0	+ 5
DC10-30	+ 3	0	- 32	+ 35
L1011	+ 13	0	0	+ 13
SUB TOTAL	+ 190	0	- 218	+ 408
<u>Developments and New Designs</u>				
A300-600	17	0	0	+ 17
B737-300	+ 78	0	0	+ 78
DC-70	+ 107	0	0	+ 107
DC9-80	+ 199	0	0	+ 199
A310	+ 70	0	0	+ 70
A320	0	0	0	0
BAe 146	+ 38	0	0	+ 38
B757	+ 74	0	0	+ 74
B767	+ 128	0	0	+ 128
F100	0	0	0	0
SUB TOTAL	+ 711	0	0	+ 711
GRAND TOTAL	+ 729	- 1134	+ 744	+ 1119

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by means of noise footprint assessment. The Committee was however informed that the use of footprints for noise certification purposes had been considered in the past and had not been accepted because the noise contour methodology involves some degree of approximation and was therefore unsuitable for use in regulatory specifications. After some discussion, it was agreed to include further study of this aspect in the future work of the Committee.

3.2.3.5 With regard to the proposal for limitation on production and operation of aeroplanes being fitted with hush-kits and aeroplanes certificated to the requirements of Chapter 2, Part II of Annex 16, Volume I, it was noted that this question had been discussed in great detail at the CAN/7 meeting and the conclusions reached at that meeting were still valid. The operational aspects were considered to be outside the terms of reference of the Committee. However, the Secretary was requested to bring the details of the proposal to the attention of the Council when the report of the meeting is reviewed by that body.

3.2.3.6 The Committee noted the information provided by the member nominated by Brazil on the Brazilian requirements for aircraft noise certification and the information provided by the member nominated by the United States on Boeing 707 and DC-8 acoustic modification programmes.

3.2.4 Noise abatement operating procedures

3.2.4.1 According to its terms of reference, the Group was required to investigate "ways in which noise certification procedures might be amended to encourage the adoption of improved noise abatement technology especially the programmed techniques . . .". This subject has been considered on a number of occasions, both within ICAO and elsewhere and there is a considerable body of evidence to show that techniques which include programmed management of airspeed, thrust, and flap and landing gear deployment during approach can reduce noise under the approach path. A proposal which had been submitted to CAN/7 involving an additional (optional) measuring point under the approach path was reviewed by the Group. According to the proposal, aeroplanes which had the capability for reducing noise during approach at points remote from the 2 km reference points should be allowed a proportion for this potential reduction in their certificated noise levels.

3.2.4.2 Although the proposal seemed sound in principle, the Group believed that there was no guarantee that the potential noise reductions would be achieved on any given occasion until a majority of the aeroplanes using an airport could employ the automated procedures, while if more than a small proportion (but not a majority) were able to do so, this might impose limits on airport utilization. Some members of the group believed that automated procedures could make a useful contribution to the improvement of the noise climate and that a mechanism might be found for encouraging their use. They believed that it might be possible to include allowances for automated procedures eventually, and that this should be kept in mind for the future work programme.

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the sum of the 90% confidence limits of the full thrust and cutback thrust noise levels. As a compromise, this Note recommends that the maximum PNLT value after cutback exceed the PNLT value before cutback by a minimum of 10.5 dB. One member stated that such a provision actually penalized newer, quieter aircraft in comparison with a difference of only 10.0 dB. After discussion, the Committee decided to accept the Note as drafted by the Working Group.

3.2.5.4 The Committee agreed that a provision should be made for the subsequent amendments of the Technical Manual to take into account the developments in the technology and the experience gained with the application of the material in the manual. Further discussion on this aspect is reflected in the report on Agenda Item 5 - Future activities.

3.2.5.5 Accordingly, the following recommendations were developed:

RECOMMENDATION 3/2 - ICAO ENVIRONMENTAL TECHNICAL MANUAL

The material in Attachment A to this part of the report be issued as an "Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft".

RSPP

RECOMMENDATION 3/3 - AMENDMENT OF ANNEX 16, VOLUME I - EQUIVALENT PROCEDURES

That Annex 16, Volume I be amended as follows:

a) Delete Attachments B and G.

b) Amend the text of the existing Note at the end of Chapter 3 and Chapter 5 as follows:

"Note.- Guidance material on the use of equivalent procedures is **provided** in the 'ICAO Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft (Doc ----)'".

c) Add the following note at the end of the text of Chapters 2, 6 and 8:

"Note.- Guidance material on the use of equivalent procedures is **provided** in the 'ICAO Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft (Doc ----)'".

d) In Appendices 1 and 2, amend the Note at the end of paragraph 2.1.1 to read as follows:

"Note.- Many applications for a noise certificate involve only **minor** changes to the aeroplane type design. The resultant

the sum of the 90% confidence limits of the full thrust and cutback thrust noise levels. As a compromise, this Note recommends that the maximum PNL T value after cutback exceed the PNL T value before cutback by a minimum of 10.5 dB. One member stated that such a provision actually penalized newer, quieter aircraft in comparison with a difference of only 10.0 dB. After discussion, the Committee decided to accept the Note as drafted by the Working Group.

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"Note.- Many applications for a noise certificate involve only minor changes to the aeroplane type design. The resultant

"... by an approved method such as that given in Section 2.2.1 of the 'ICAO Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft (Doc ----)'".

i) In Appendix 3, amend the text at the end of 4.2.1.2 as follows:

"... being certificated shall be used as described in Section 4.1 of the 'ICAO Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft (Doc ----)'".

3.2.6 Improvements in noise certification test and analysis procedures

3.2.6.1 The specific items investigated by the Working Group arising from its **terms of reference** and the comments of States on the related CAN/7 recommendations include the following:

- a) microphone height;
- b) extensions to the test window;
- c) revision of the reference atmosphere;
- d) reference value of atmospheric absorption variation, Annex 16, Attachment B, para 2.6.1 c);
- e) pseudo-tone identification;
- f) equations for NOY function generators - Annex 16, Appendix 2, Section 7;
- g) the need for digital systems specifications for acoustic measurement and analysis;
- h) **aeroplane** reference point during approach measurements;
- i) amendments to Annex 16, Volume I to remove references to ISO 3891 - 1978(E);
- j) tone correction procedures;
- k) review of measurement framework;
- l) integrated procedures.

The investigation by the group had been undertaken with the assistance of a Technical Issues Subgroup. The result of the investigation as presented in the Working Group report were reviewed by the Committee and its recommendations are presented below.

"... by an approved method such as that given in Section 2.2.1 of the 'ICAO Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft (Doc ----)'".

i) In Appendix 3, amend the text at the end of 4.2.1.2 as follows:

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and the development of background noise correction methods, no change should be recommended. It was however recognized that, should a major change in noise certification procedures become necessary in the future, further serious consideration should be given to adopting a reference atmosphere closer to test day conditions thereby reducing the magnitude of the atmospheric attenuation adjustment. The Committee accepted the views of the Working Group.

3.2.6.4.2 It was pointed out that there was a significant influence of changes in wind direction in jet aeroplane noise levels at the lateral measurement point. In some cases the variations in noise levels due to changes in wind direction and wind speed during testing could be as much as 8 EPNdB. In order to improve the reliability of the noise level measurements at the lateral measurement point, it was suggested that paragraph 2.2.3 d) of Appendix 1 and paragraph 2.2.2 f) of Appendix 2 be reviewed to stipulate the acceptable range of wind direction. The Committee agreed that this problem should be included in its future work programme.

3.2.6.5 Reference value of atmospheric absorption variation

3.2.6.5.1 In response to the CAN/7 recommendations it had been suggested that in Attachment B to Annex 16, Volume I the value of ± 0.5 dB/100 m for variation in atmospheric absorption, when using layered sections, must be defined relative to some definite value, such as the absorption coefficient derived from meteorological measurements obtained 10 m above the surface. This suggestion had been referred to the Working Group for study.

3.2.6.5.2 The Committee reviewed the Working Group's proposal which included a suitable additional text for paragraph 2.2.2 of Appendix 2 to the Annex and agreed to its inclusion in the proposed amendment to the Annex.

3.2.6.6 Pseudo-tone identification

The Committee noted that a number of methods for identifying pseudo-tones had been included in the Environmental Technical Manual developed by the Working Group (see Attachment A to this part of the report).

3.2.6.7 Equations for NOY function generators

3.2.6.7.1 In response to the CAN/7 recommendations it had been suggested that the mathematical relationship between sound pressure level and perceived noisiness (SPL-NOY) given in paragraph 7.3 of Appendix 2 of Annex 16, Volume I should be supplemented by guidance material giving the background and details of the basis used in the development of this relationship.

3.2.6.7.2 Based on the advice of the Working Group, the Committee concluded that the existing text was suitable for use by noise certification authorities without further guidance, and that it was considered to be more logical and simpler than the original text. In view of this it was considered that there was no need to develop additional guidance material.

3.2.6.7.3 The Committee also agreed to the Working Group's proposal to modify the equation in 7.3 c) of Appendix 2 of the Annex to make it consistent with the format of 7.3 b) and 7.3 d).

3.2.6.8 Digital systems for acoustic measurement and analysis

The Committee was informed that because of advances in technology, digital systems are becoming increasingly used for the measurement and analysis of aircraft noise and that such systems offered significant advantages over the older analogue systems. Recognizing that this was a highly specialized subject and the American National Standards Institute (ANSI) and the International Electrotechnical Commission (IEC) were already working on such Standards, it was agreed that IEC be requested to develop appropriate standards for aircraft noise measurement and analysis systems. Accordingly, Recommendation 3/4 was developed as follows:

RECOMMENDATION 3/4: DIGITAL EQUIPMENT FOR AIRCRAFT NOISE MEASUREMENT

That the International Electrotechnical Commission (IEC) be requested to develop specifications for digital equipment for use in aircraft noise measurement and analysis for the purpose of noise certification.

3.2.6.9 Aeroplane reference point during approach measurement

During development of the Environmental Technical Manual it became apparent that although Annex 16, Appendix 1, paragraph 5.4.2.1 b) defines the ILS antenna as the reference point on the aircraft for approach noise measurement; there was no corresponding definition in Appendix 2. It was therefore agreed to rectify this deficiency by inclusion of a new paragraph 9.2.2 in Appendix 2.

3.2.6.10 Removal of references to ISO 3891

The Committee noted that ISO will be removing references to aircraft noise certification information from ISO 3891-1978(E) which will then become more applicable to aircraft noise monitoring. It was therefore agreed to include appropriate material in Annex 16, Volume I to make it self-contained and to delete the references to ISO 3891.

3.2.6.11 Integrated procedures

3.2.6.11.1 A proposal was submitted for the amendment of Section 9 of Appendix 2 of Annex 16, Volume I and for the inclusion of a new Attachment in the Annex to identify an accepted method of adjustment to test results for use in the noise certification of aircraft. It was also suggested that a standing group of experts be established to study, among other items to be assigned to it, the suitability of alternative "integrated" adjustment methods for noise measurement to be included as a new Section in possible future editions of the Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft.

It was stated that the proposed amendments were intended to broaden the scope of the applicability of the "integrated" adjustment method which had technically matured in recent years and to provide an example of the computational procedures involved. It was also intended to provide incentive for technical groups to continue evaluation of acoustical data adjustment methods including the quantification of assumptions relative to the magnitude of lateral attenuation effects. It was added that the method had been accepted for contour methodology and could be used satisfactorily for certification purposes.

3.2.6.11.2 The Committee noted that the task of developing the related material had been assigned to the Working Group. Although several proposals had been developed, the group had not found it possible, due to lack of time, to assess them. As such, no specific recommendations had been developed. The Committee reviewed the proposal presented in 3.2.6.11.1. While it had no problem in accepting the proposed amendment to paragraphs 9.1.2 to 9.1.4 of Appendix 2 extending the use of the integrated method to lateral noise measurements, and to remove the **anomalies** pointed out, it was considered that the guidance material would require a more detailed study. It was therefore agreed to include this task in the future work programme of the Committee. It was also considered that the guidance material, when developed, may be more suitable for inclusion in the Environmental Technical Manual.

3.2.6.12 Tone correction procedures

3.2.6.12.1 The Committee noted that the Working Group had considered a suggestion for **re-examination** of tone correction aspects of the EPNL calculation to cater for the new generation of propeller-driven **aeroplanes** and the probable development of "open rotor" type of powerplant in the next few years. Some researchers had identified deficiencies in the ability of low frequency tone corrections to correlate with annoyance for large propeller-driven **aeroplanes** and it had been suggested that the correlation could be improved by eliminating the **tone** correction below 500 Hz for such **aeroplanes**.

3.2.6.12.2 The Committee also noted that, in view of the limited data available, the group had not been able to support this suggestion, it being argued that the EPNL had been developed to put jet and propeller **aeroplanes** on an equal footing. If a change was applied to one class of **aeroplanes** only this would mean that a different noise metric would be introduced, putting jet **aeroplanes** and helicopters into *one* class and heavy propeller-driven types into another. If the change was applied universally it could reduce the reported noise levels of jet propelled **aeroplanes** by 1-2 dB.

3.2.6.12.3 After some discussion, it was agreed to include this task in the future work programme of the Committee.

3.2.6.13 Review of measurement framework

3.2.6.13.1 Recognizing that the progressive reduction of demonstrated noise levels, background noise during testing had taken greater significance, the Working Group considered that a review of the distances between the start of roll

and the take-off measurement **centre** line point on one hand and lateral measurement points and the take-off track on the other hand was desirable. It was stated that if these distances could be reduced, the problem of background noise would assume less importance.

3.2.6.13.2 The Committee noted the above observation of the Working Group and agreed to include this task in its future work programme. It was recognized that there may be a problem with regard to the sideline noise due to ground effects.

3.2.6.14 Aeroplane configuration during approach

3.2.6.14.1 It was pointed out that Chapters 3 and 5 of Part II of Annex 16, Volume I stipulate in paragraphs 3.6.3.1 e) and 5.6.3.1 e) that "the most critical (that which produces the highest noise levels) configuration at the mass at which certification is requested, shall be used". This has normally been interpreted as being with the maximum approach flap. However, cases had occurred where this was not necessarily the noisiest configuration. Some propeller-driven **aeroplanes** had demonstrated the highest approach noise level with a flap angle of less than that used during a full flap approach. Differences in approach noise levels between cases with airbrakes stowed or deployed could exceed one **EPNdB**.

3.2.6.14.2 In order to clarify the standard with the aim of achieving a uniformity of interpretation it was proposed to add suitable explanatory notes to paragraphs 3.6.3.1 e) and 5.6.3.1 e) of Part II of Annex 16, Volume I.

3.2.6.14.3 The Committee reviewed the proposal and agreed to rectify the deficiency by amending the text of paragraph 3.6.3.1 e) of the Annex. It was felt that a similar amendment to Chapter 5 was unnecessary since there were no **aeroplanes** being certificated at present to the Chapter 5 requirements. By virtue of paragraph 5.1.4 of this Chapter all **aeroplanes** for which the application for the prototype is accepted on or after 1 January 1985 is required to comply with the provisions of Chapter 3 of the Annex. It was considered that it may be an opportune time now to amend editorially Chapter 3 to include both subsonic jet **aeroplanes** for which the application for type certification is accepted on or after 6 October 1977 and heavy propeller-driven **aeroplanes** for which the application for type certification is accepted on or after 1 January 1985. Accordingly, suitable amendments to the Annex were developed.

3.2.6.15 Reference take-off power/thrust engine rating

3.2.6.15.1 It was pointed out that currently the requirements of Chapter 3, Part II of Annex 16, Volume I do not stipulate the take-off power rating which should be used for reference conditions. The certificating authorities are therefore left with an interpretation to be made. It was reported that most have adopted the average engine rating whereas some others use the minimum acceptance engine rating.

3.2.6.15.2 It was explained that for take-off with power cut-back the minimum acceptance engine rating would give a lower height at the cut-back point than the average rating and since the subsequent cut-back power levels would be the same

in both cases, i.e. that for a 4% gradient or for level flight with one engine inoperative, the minimum acceptance rating would lead to a higher noise level at the noise measuring point. For a modern high by-pass ratio engine aeroplane this increase was in the order of 0.7 EPNdB. In the lateral noise case the peak noise would occur at the same height in both cases and the noise levels would only be affected by the change in engine power; the minimum acceptance rating would lead to a lower noise level. For a modern aeroplane this is in the order of 0.5 EPNdB.

3.2.6.15.3 It was therefore considered that from a noise certification viewpoint the noisier overall rating should be adopted and although the difference in noise level between the ratings was small in the case considered the minimum acceptance rating was marginally higher. Further, for performance take-off calculations minimum acceptance engine power/thrust rating was now almost universally used. It was proposed therefore that, in the interests of consistency between authorities dealing with noise certification and performance certification, the minimum acceptance engine rating be adopted for the calculation of the reference flight path and the related noise levels.

3.2.6.15.4 The *concern* expressed above was not shared by the majority of the members. It was explained that the take-off power used to determine the reference trajectories and noise level must be the average engine power representative of the mean characteristics of the production engines. This interpretation had been adopted in several States and had caused no confusion. However, to clarify this point, it was agreed to insert "**average**" in front of "**take-off**" in paragraphs 2.6.1.1, 3.6.2.1 a) and 5.6.2.1 a) of Part II of Annex 16, Volume I.

3.2.6.16 Aeroplane configuration during take-off

It was pointed out that specifications contained in Annex 16 were insufficiently precise with regard to the correlation between the stipulated noise levels and an aeroplane's take-off configuration, as well as to the corresponding flight procedures during noise certification testing, and this resulted in a discrepancy between the noise levels recorded during day-to-day operating conditions and those obtained at the time of certification. It was suggested that suitable recommendations be developed during the future work of the Committee to make the aeroplane noise conditions correspond more closely to day-to-day operating conditions. After a brief exchange of views the Committee agreed to include this task in its future work programme.

3.2.6.17 In the light of the foregoing, the following recommendation was developed:

RSPP

RECOMMENDATION 3/5 - AMENDMENT OF ANNEX 16, VOLUME I - NOISE CERTIFICATION TEST AND ANALYSIS PROCEDURES

That Annex 16, Volume I be amended as indicated in Attachment B to this part of the report.

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noise indices used in States could be satisfied to an acceptable order of accuracy by using these two descriptors with conversion factors, as appropriate. Some members of the group, however, believed that all four descriptors should be retained as they felt that this would not impose undue burden on manufacturers in providing noise information for their products. Some manufacturers have preferred to have only one unit.

- c) The method described in the methodology suggests that the flight profile preferably be presented as a series of straight line segments with their associated values of speed and thrust Or power for each of two ICAO noise abatement take-off procedures and for the Annex 16 noise compliance approach procedure. Where other procedures are used or the aeroplane operating conditions are different, the flight profile information can be calculated from a set of equations.
- d) Guidance is given in the method for the spacing of the grid of points to be used in calculating noise on the ground, the modelling of lateral dispersion of the real aeroplane tracks about the nominal departure tracks, the geometric relation of the aeroplane to the grid points, and interpolation of the noise-power-distance data used as a basic input for each aeroplane type. A method for determining the additional attenuation due to the influence of the ground is included. Guidance is also given on the construction of contours of equal noise level from the values calculated over the field of grid points.
- e) A procedure to establish noise levels during the ground roll is included, but no means of allowing for the overlap of the take-off and landing roll is given as it was considered that this was related to single event noise footprints which were outside the scope of the methodology. Other aspects which are not included are noise due to the running of APU and noise due to thrust reversal during the landing roll. Although the latter can affect the environment close to the airport, there has been no systematic attempt to collect the necessary source noise data. This is because: (i) reverse thrust noise is specific to the aeroplane-engine combination; (ii) it cannot be measured under test bed conditions; and (iii) it is not amenable to theoretical treatment."

3.2.7.4 The Committee further noted the comparison, made by a member, of methods of calculating noise contours around airports developed by SAE, ECAC and the Working Group. The methodology approved by the Committee is presented in Attachment C to this part of the report. It was agreed that this material should be issued in the form of an ICAO Circular. Consequently, it will be necessary to amend Part IV and delete Appendix 6 and Attachment F of Annex 16, Volume I and

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- c) the footnote on page 2-17 of the ICAO Airport Planning Manual (Doc 9184-AN/902, Part 2) be amended to refer to Attachment C of the new circular recommended in a) above.

3.2.7.6 The Committee agreed that provisions should be made to allow for the amendment of this Circular in accordance with technical progress.

3.2.8 Exemption for special category aeroplanes

3.2.8.1 The Working Group had been asked to review the need for exempting from the Standards of Annex 16 aeroplanes manufactured in small number for very specific tasks such as the carriage of large and unusual cargo.

3.2.8.2 The Committee endorsed the conclusions of the Working Group on this subject and agreed that in view of the small number of aeroplanes involved (approximately 10) the size of the problem did not justify any action by ICAO and that any international operational problems which might arise should be settled by negotiation between the States concerned.

3.2.9 Derived versions

3.2.9.1 The Working Group during its consideration of the various problems had noted that the existing definition of "Derived Versions of an Aircraft" in Part I of Annex 16, Volume I could be interpreted as to require that a modified aeroplane, although quieter than its prototype, meets more stringent standards than the prototype. This could inhibit the development of desirable derivatives which showed only modest noise improvements. The Group believed that the intent behind the introduction in Chapter 2 of more stringent Standards for derived versions was to prevent the growth of noise by subsequent development where the prototype showed noise levels which were significantly below the initial Standard. The Group therefore recommended that the word "adversely" should be introduced after "characteristics" and that the definition be supplemented by an additional note explaining that where more than one measurement point is involved, "adversely" would refer to the net change in noise levels.

3.2.9.2 Some members felt that adoption of this proposal would be equivalent to a deletion of the derived version standards and would create a peculiar situation in that a derivative, incorporating a change in type design that was specifically developed to reduce noise levels would be required to meet less stringent noise level requirements specified in paragraph 2.4.1 of Part II of Annex 16, Volume I whereas a derivative incorporating a change in type design that may increase its noise levels would be required to meet the more stringent requirements specified in paragraph 2.4.2 of the Annex. They emphasized that the present definition had been developed after a lengthy discussion at CAN/6 meeting and met the objectives agreed upon at that meeting and as such required no change.

3.2.9.3 The members supporting the Working Group's proposal were however of the opinion that the present definition, as written, would result in a modified version of an aeroplane with lower noise levels being treated as a derived

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3.2.12 Applicability of Chapter 3 to all derived versions

3.2.12.1 It was proposed that beginning in 1988, Chapter 3 requirements should become applicable to all derived versions of subsonic jet aeroplanes. It was stated that in the years to come, improvement in acoustic environment around airports will be due essentially to the replacement of Chapter 2 aeroplanes by Chapter 3 aeroplanes. Under these conditions, to permit the development of derived versions of aeroplanes satisfying only Chapter 2 noise levels requirements would be a retrograde step that would be difficult to justify.

3.2.12.2 Although supported by some members, this proposal was not accepted by the Committee.

3.2.13 Standardization of noise certificate

3.2.13.1 It was suggested that the format of the document attesting compliance with the relevant noise certification requirements be standardized to facilitate international acceptance of the document. A sample of the document was provided which identified the type of information that may be included in the standardized form.

3.2.13.2 It was pointed out by several members that their national regulations did not require a separate noise certificate to be issued. Noise certification was considered as a part of airworthiness certification and detailed information such as noise levels was included in the aeroplane flight manual. Furthermore, detailed guidance on the type information to be provided was already given in Chapter 1, Part II of the Annex. After some discussion, however, it was agreed to include further study of the proposal in the future work of the Committee, it being recognized that there may be some merit in providing a separate certificate containing the noise certification information as a proof of the aircraft satisfying the relevant noise certification requirements. Such a certificate may facilitate operations into those airports where the authorities require such a proof to be produced.

3.2.14 Noise level. data

The Committee was provided with noise certification test results for subsonic jet aeroplanes of the USSR manufacture. It was suggested that the Committee prepare a composite document containing the results of certification tests and evaluations on the acoustical performance of subsonic jet aeroplanes from different countries. While appreciating the information, it was pointed out that a noise data bank had been established in the United States and that State published the data on a regular basis. No decision was taken.

3.3 Summary of future work

The discussions reported above led the meeting to agree to the following list of items for further study:

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operating conditions of the propeller when run statically compared with conditions existing during flight. The propeller noise levels measured during a static test can include significant contributions from noise source components not normally important in flight. However, limited static tests on engines with propellers, which are used as engine loading devices can be utilised to determine small noise changes, as described below.

- 3.3.2 Guidance on the test site characteristics, data acquisition and analysis systems, microphone locations, acoustical calibration and measurement procedures for static testing is provided in SAE AIR 1846-1984 and is equally valid in these respects for propeller power plants.
- 3.3.3 Static tests of the gas generator, can be used to identify noise changes resulting from changes to the design of the gas generators or the internal structure of the engine in the frequency ranges where there is a contribution to the aeroplane EPNL, or where that part of the spectrum is clearly dominated by the gas generator or ancillary equipment under circumstances where the propeller and its aerodynamic performance remains unchanged.

Such circumstances include, for example, changes to the compressor, turbine or combustor of the powerplant. The effect of such changes should be conducted under the same test, measurement, data reduction and extrapolation procedures as described in paragraph 2.3 for turbojet and turbofan engines. The noise from any propeller or other power extraction device used in static tests should be eliminated or removed analytically. For the purposes of aeroplane EPNL calculation, the measured flight datum aeroplane propeller contributions should be included in the computation process.

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SECTION 5: EQUIVALENT PROCEDURES FOR HELICOPTERS

(To be developed).

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noise performance parameters(μ) for the prototype and derived aeroplanes for each of the reference noise measurement sites. Provided that the 90% confidence interval limit is not greater than ± 1.5 EPNdB (or ± 1.5 dBA as appropriate) is satisfied, as calculated in paragraph 2.2 of Appendix 1 of this manual, the noise certification levels may be obtained by entering the curve of noise level versus engine noise performance parameter(μ) at the appropriate reference μ .

In some areas an extrapolation of the data field may be approved but care must be taken to ensure that the relative contributions of the component noise sources to the effective perceived noise level or A-weighted noise level as appropriate, remains essentially unchanged and that a simple extrapolation of noise/power and noise/distance curves can be made.

For propeller driven aeroplanes a change in propeller and/or power-plant may necessitate further flight tests to establish a revised noise-power-distance relationship.

6.4 Test Environment Corrections

The atmospheric conditions specified in Annex 16, Volume 1, section 2.2.2(b), (c), (d) and (e) of appendix 2 require the measurement of ambient air temperature and relative humidity profiles during noise certification tests, to ensure that the temperatures, relative humidities and corresponding atmospheric sound absorption coefficients do not deviate from the specified limits over the whole noise path between ground and aeroplane. Ordinarily, profile measurements are recorded by balloon, instrumented aeroplane, or other similar method during flight testing, in order to ensure that the criteria are met.

At the discretion of the certificating authority atmospheric profile measurements of ambient air temperature and relative humidity may be made by instruments mounted on the test aeroplane, and may be considered sufficient to determine compliance with the criteria specified in section 2.2.2(b), (c), (d) and (e).

REFERENCES

- 1 Jet mixing noise: comparison of measurement and theory.
B.J. Tester and V.M. Szewczyk, AIAA Paper 79-0570.
- 2 1974 Proceedings of the Second Inter-Agency Symposium on
University Research in Transportation Noise, Volume 1,
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J. Laufer, R.E. Kaplan and W.T. Chu.
- 3 Airframe Noise Prediction Method. **M.R. Fink, USA DOT**
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- 4 **SAE ARP 866A - 1975** Standard Values of Atmospheric Absorption as a
Function of Temperature and Humidity
- 5 **SAE ARP 876C - 1985** Gas Turbine Jet Exhaust Noise Prediction
- 6 **SAE AIR 1672B-1983** Practical Methods to Obtain Free Field Sound
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- 7 **SAE AIR 1846-1984** Measurement of Noise from Gas Turbine Engines
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- 9 **ESDU Item 80038** Amendment A The Correction of Measured Noise Spectra
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NOTES: 1 **ESDU** Data items may be obtained from **ESDU International Ltd.,**
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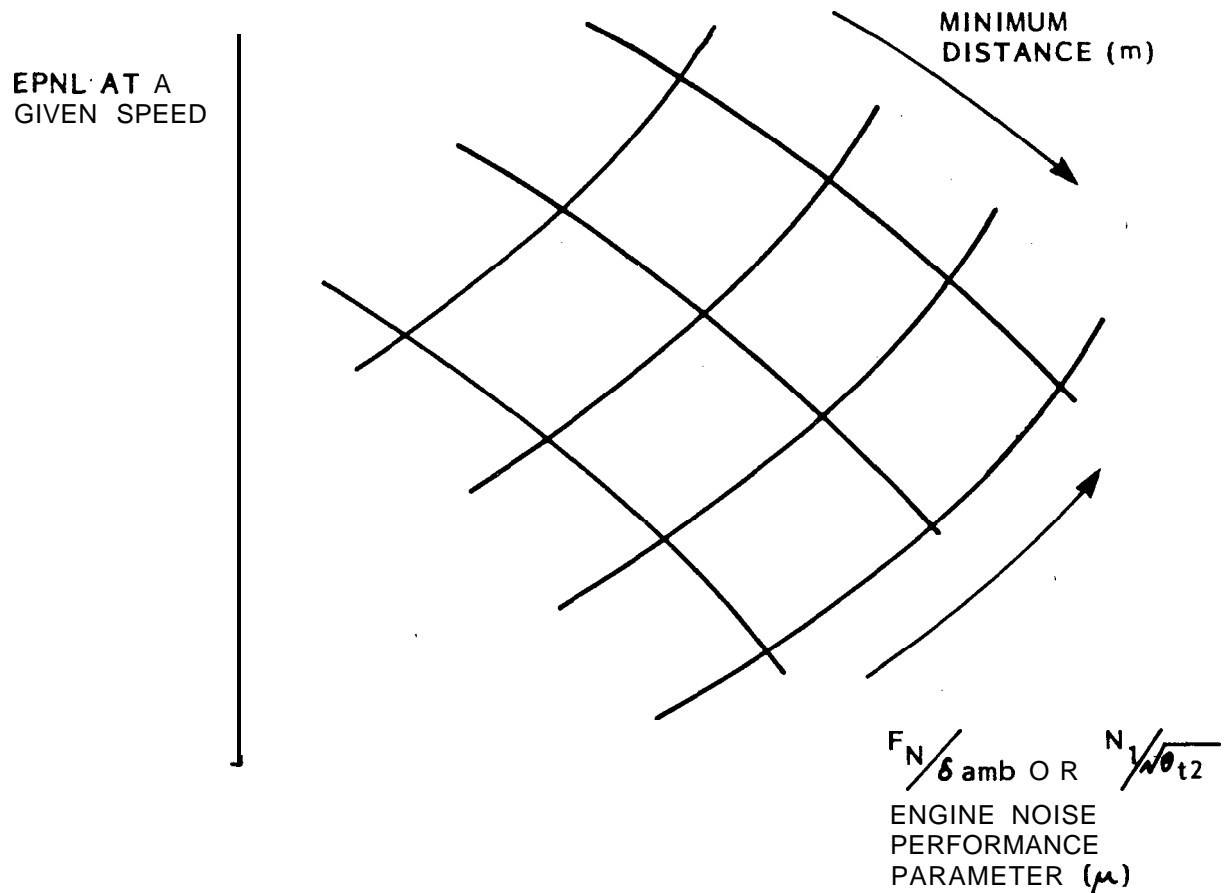


FIGURE 2

Form of NPD plot for turbo-jet or turbo-fan powered aeroplanes

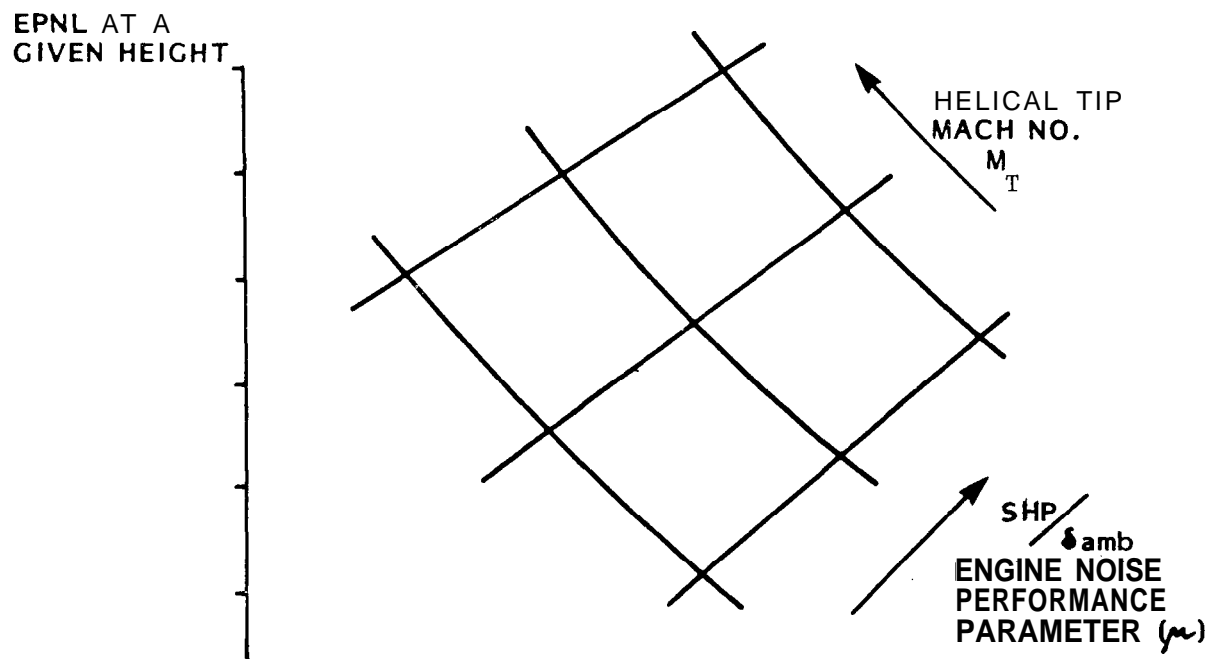


FIGURE 3

Form of NPD plot for propeller driven heavy aeroplanes

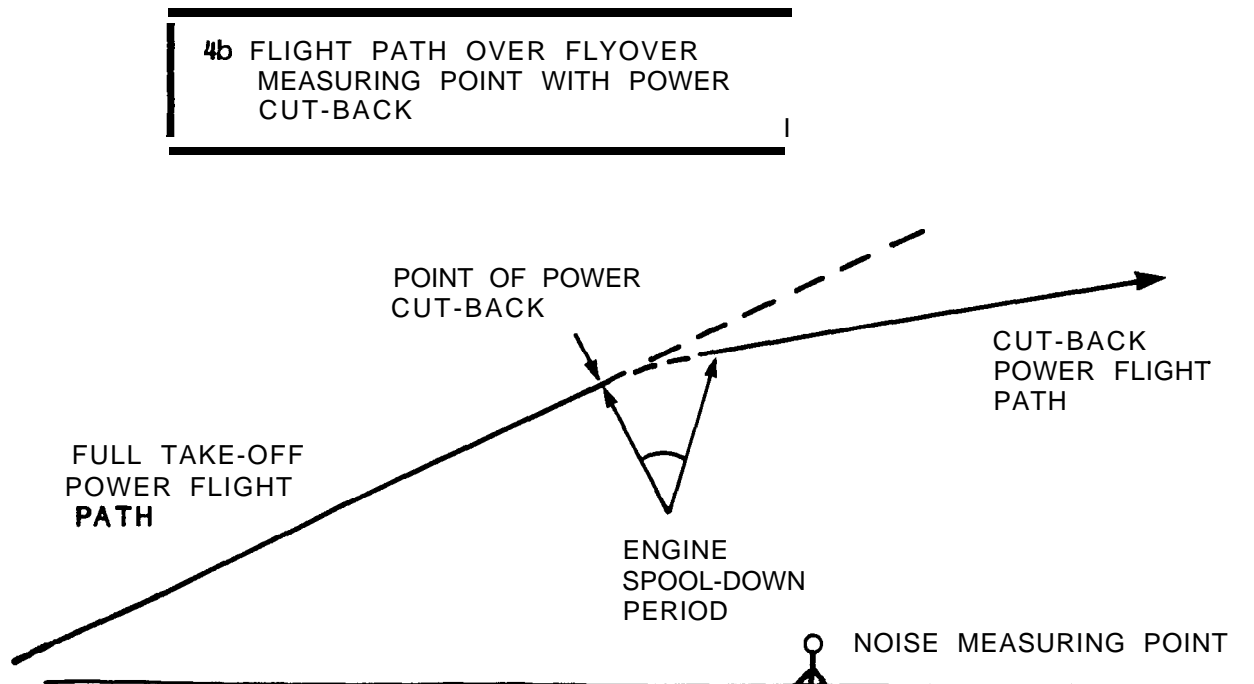
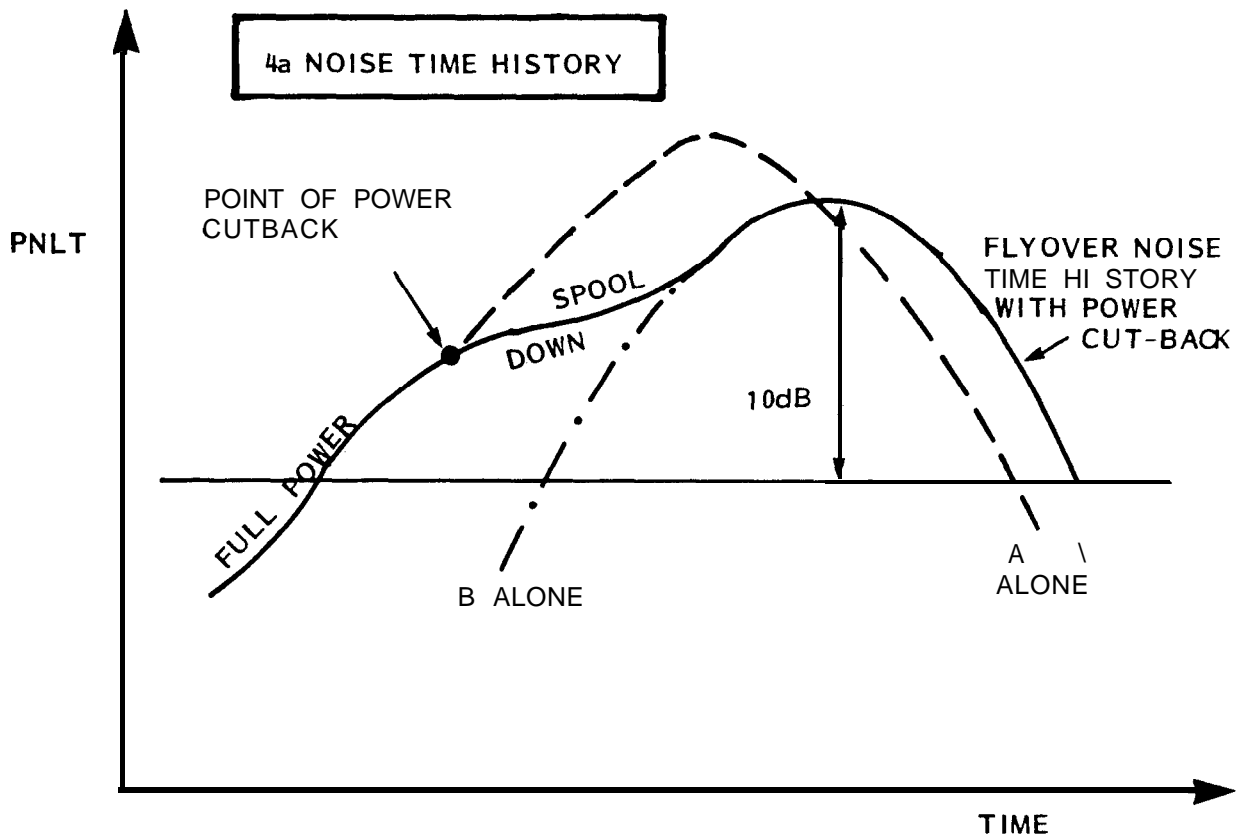


FIGURE 4

Computation of cutback-takeoff noise level from constant power tests

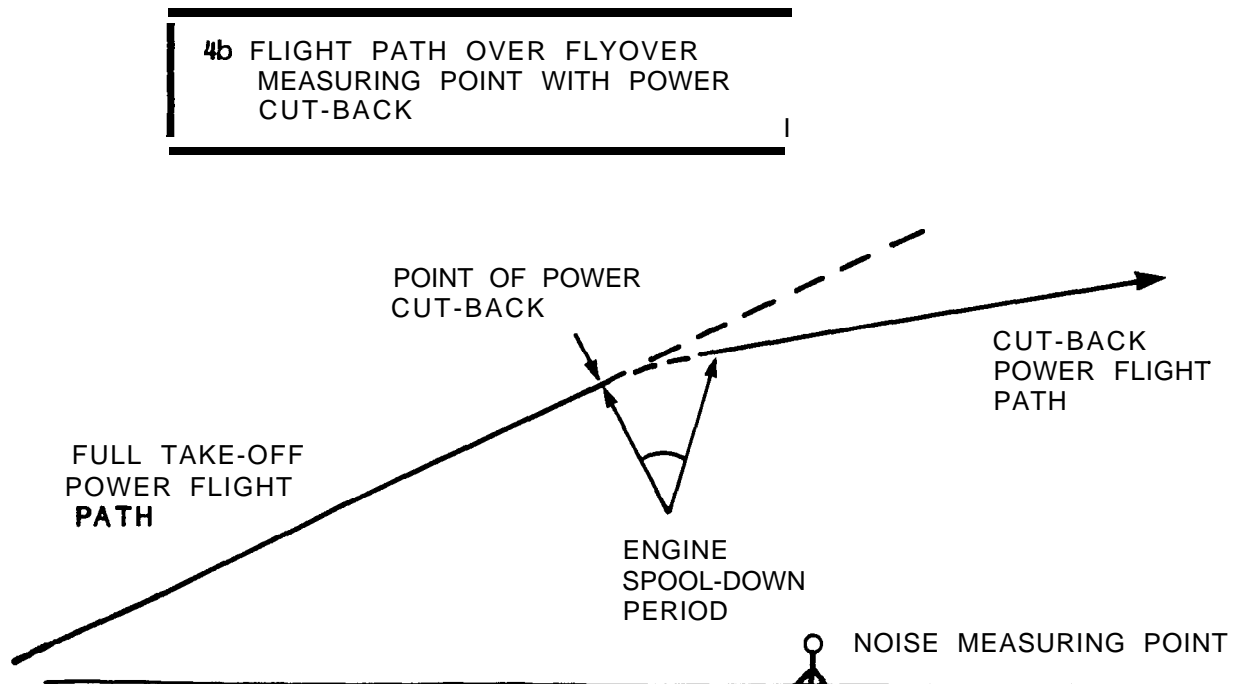
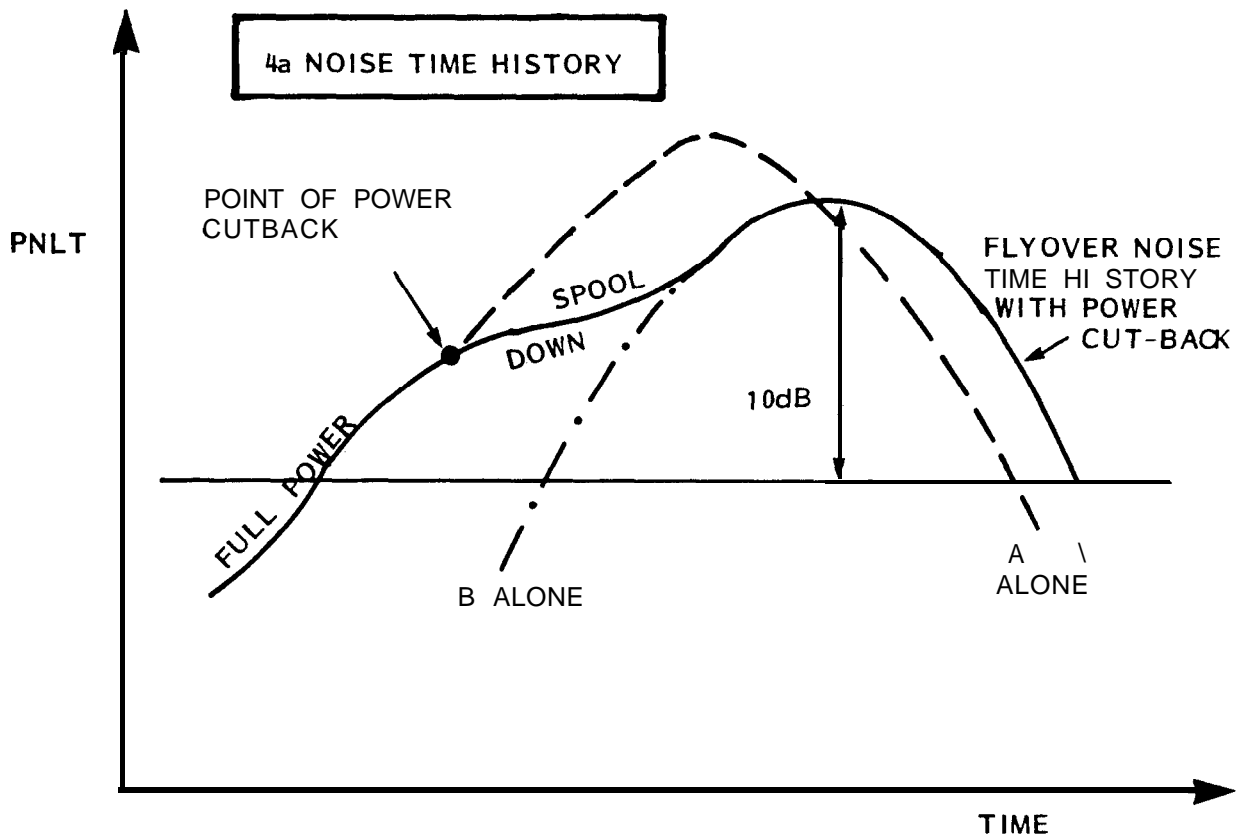
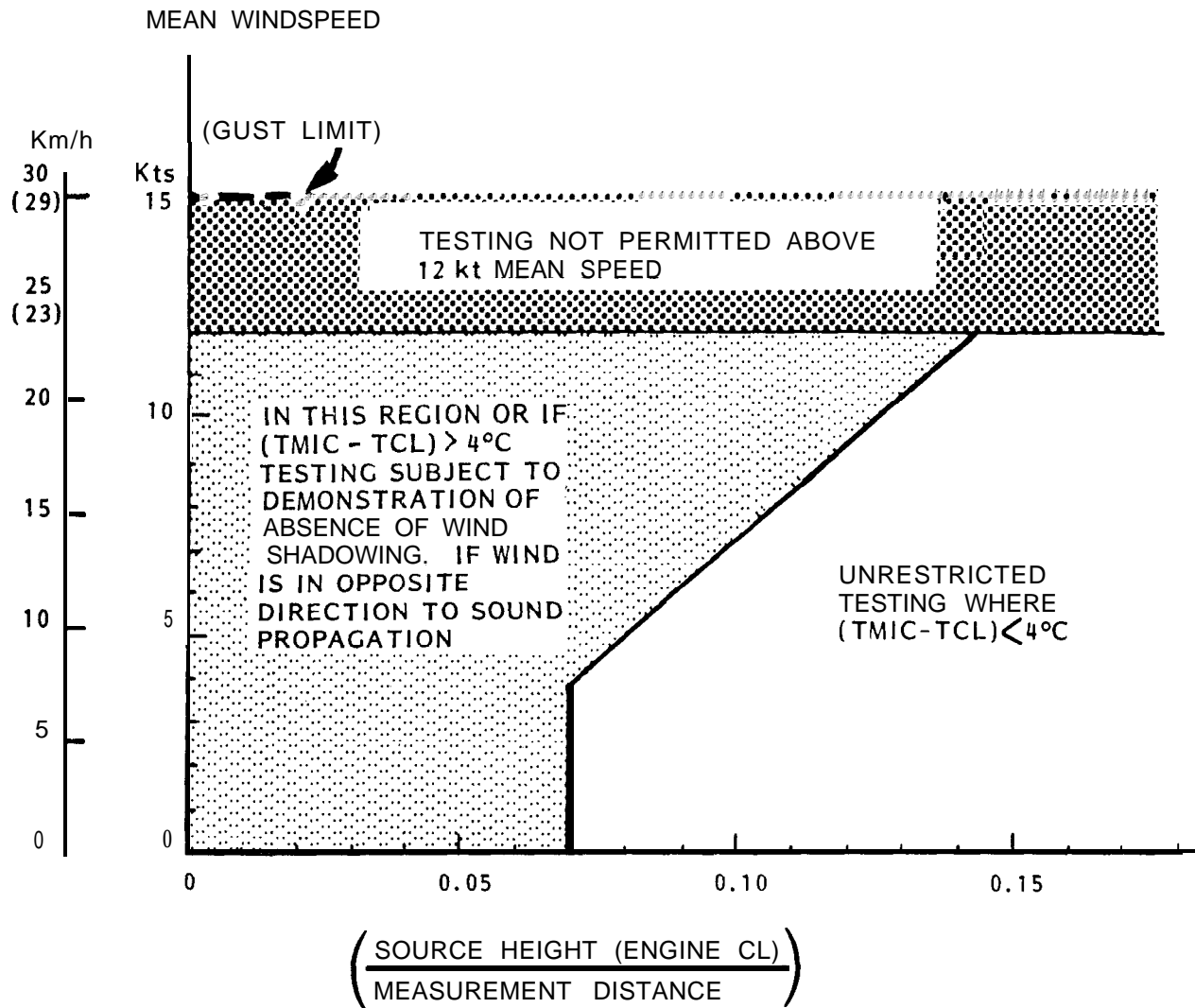


FIGURE 4

Computation of cutback-takeoff noise level from constant power tests



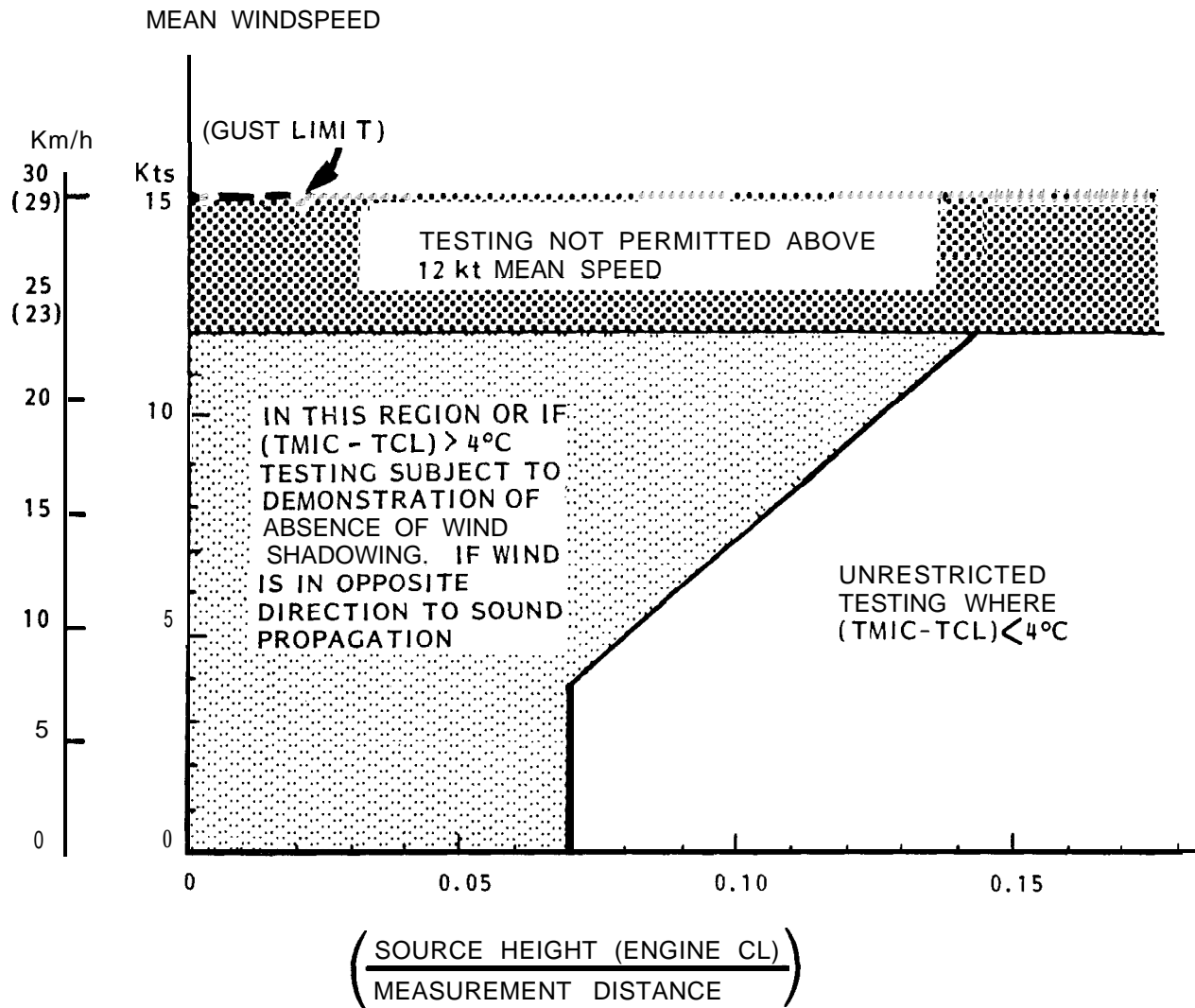
NOTE

TCL = TEMPERATURE AT ENGINE CENTRELINE HEIGHT

TMIC = TEMPERATURE WITHIN $\pm 5\text{MM}$ OF GROUND MICROPHONE DIAPHRAGM HEIGHT

FIGURE 6

Weather criteria for use with ground microphone installations



NOTE

TCL = TEMPERATURE AT ENGINE CENTRELINE HEIGHT

TMIC = TEMPERATURE WITHIN $\pm 5\text{MM}$ OF GROUND MICROPHONE DIAPHRAGM HEIGHT

FIGURE 6

Weather criteria for use with ground microphone installations

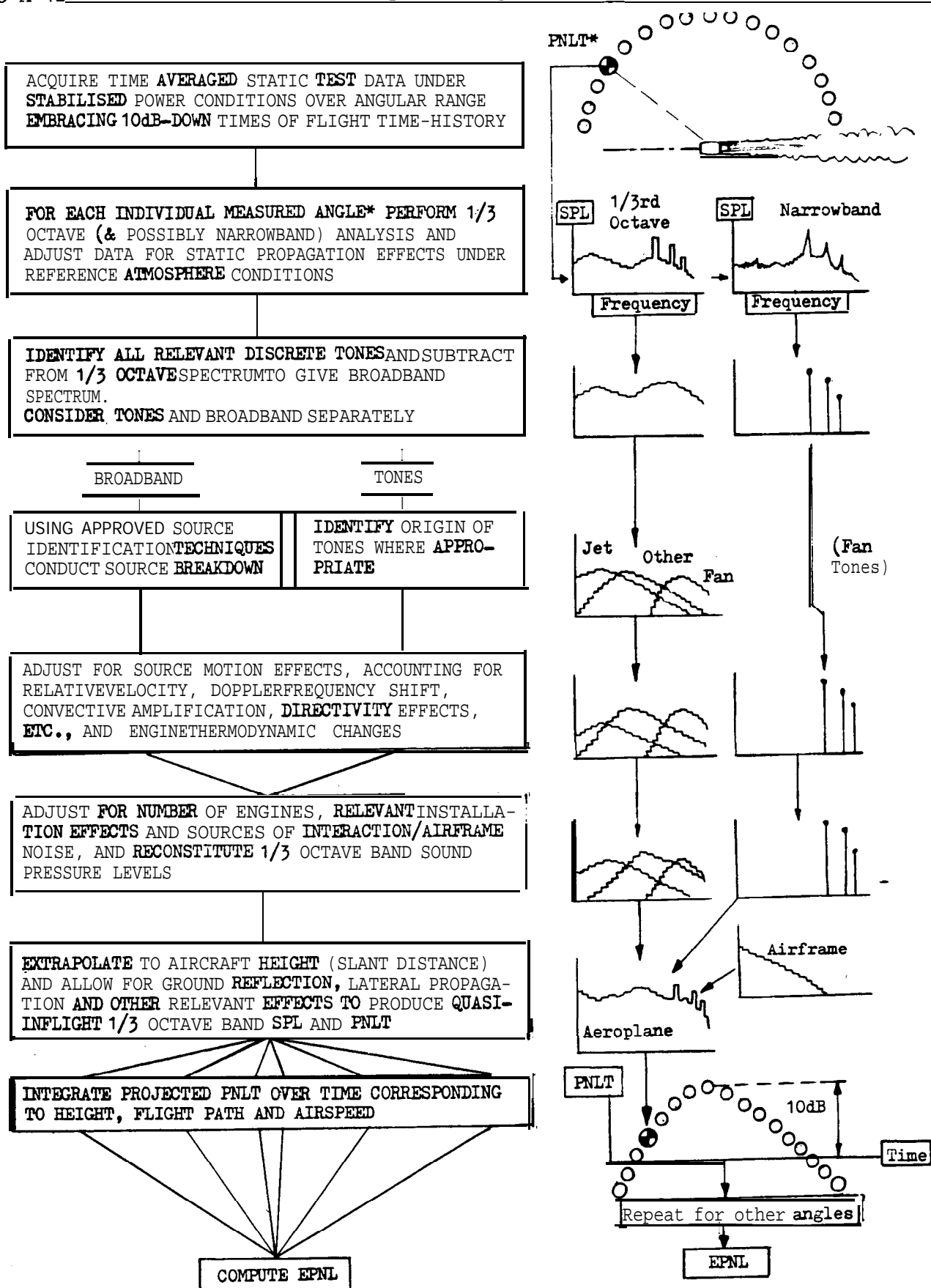


FIGURE 8

Example procedure for projection of static engine data to aeroplane flight conditions

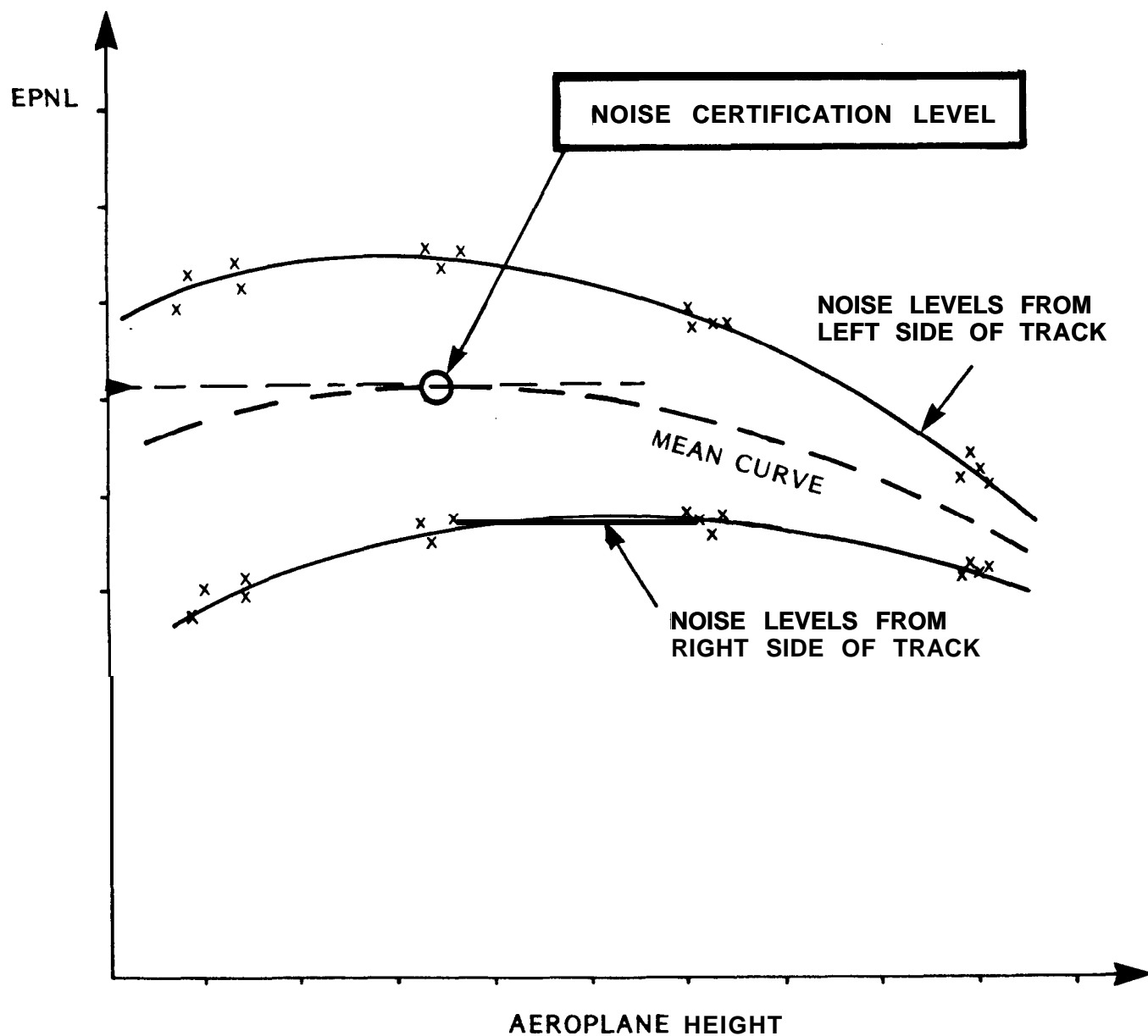


FIGURE 9

Typical lateral noise data plot for a propeller driven heavy aeroplane

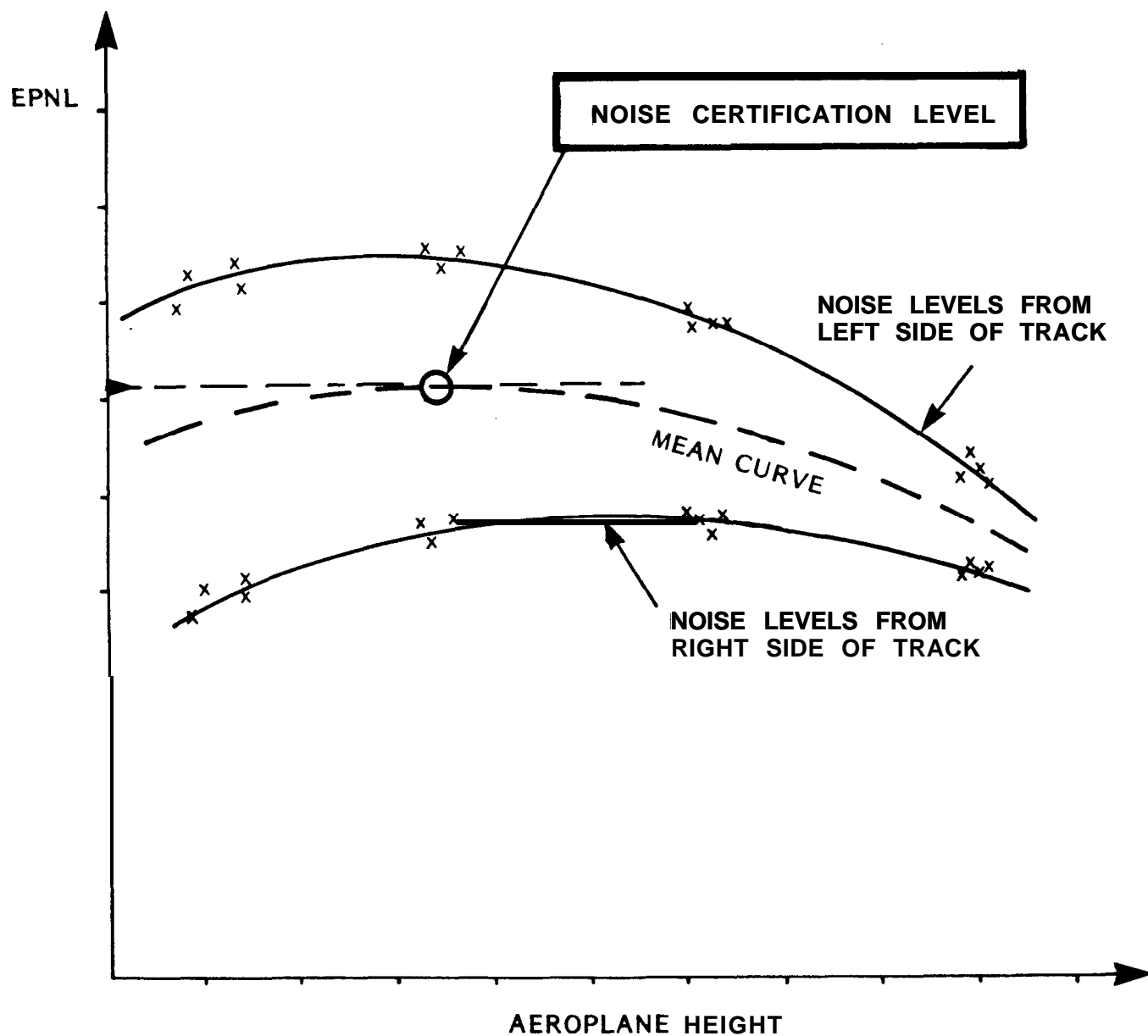


FIGURE 9

Typical lateral noise data plot for a propeller driven heavy aeroplane

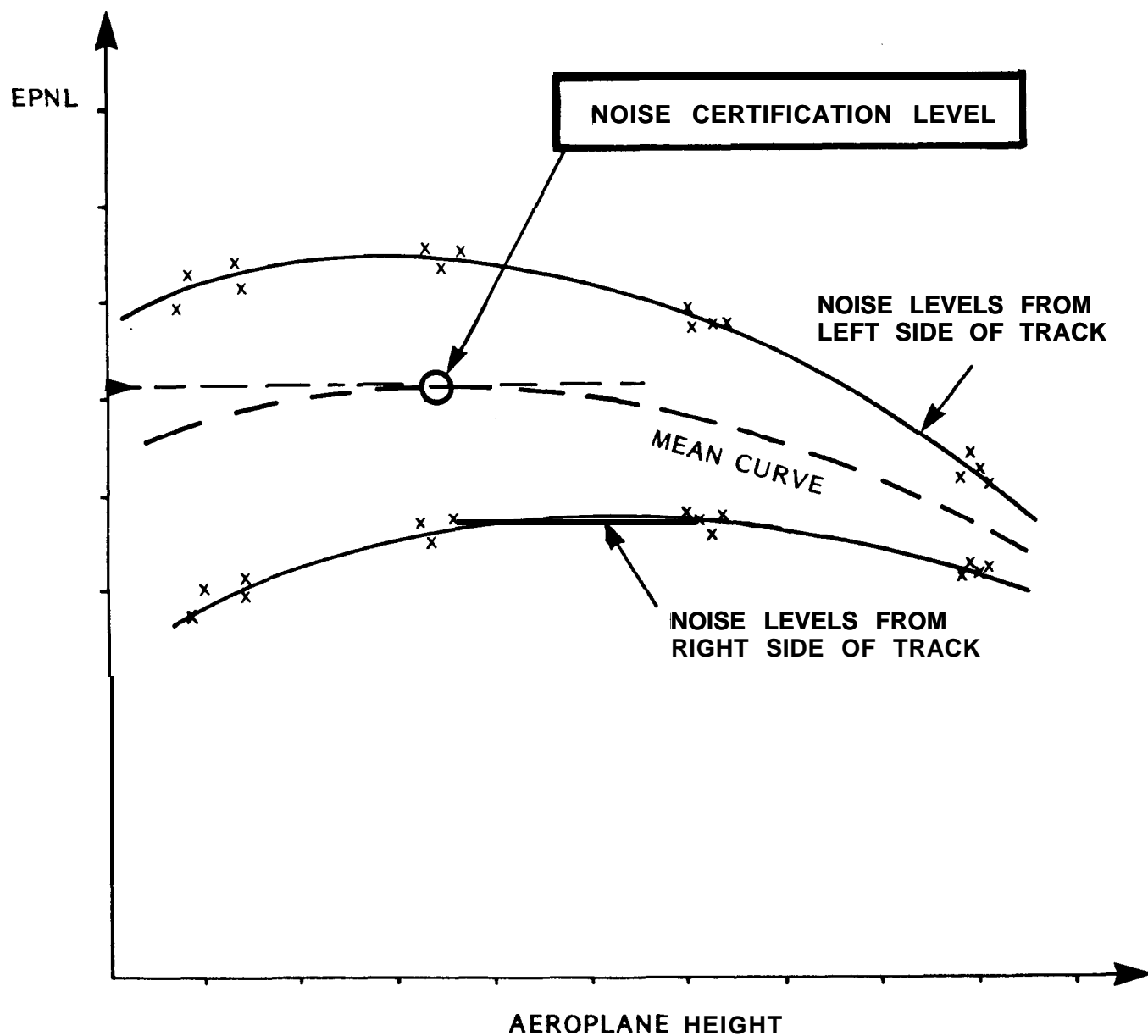


FIGURE 9

Typical lateral noise data plot for a propeller driven heavy aeroplane

We define the matrix \underline{A} such that $\underline{A} = \underline{X}' \underline{X}$
and \underline{A}^{-1} is the inverse of \underline{A} .

Also, $\underline{y} = \{y_1 \ y_2 \ \dots \ y_n\}$,

and, $\underline{b} = \{b_0 \ b_1 \ \dots \ b_k\}$ with

\underline{b} determined as the solution of the normal equations:

$$\underline{y} = \underline{X} \underline{b}$$

$$\underline{X}' \underline{y} = \underline{X}' \underline{X} \underline{b} = \underline{A} \underline{b}.$$

$$\text{so, } \underline{b} = \underline{A}^{-1} \underline{X}' \underline{y}$$

The 90% confidence interval for the mean value of the effective perceived noise level estimated with the associated value of the engine-related parameter, x_0 , is

$$\bar{y}(x_0) \pm t_{.95, \nu} s \sqrt{x_0' \underline{A}^{-1} x_0},$$

where $\underline{x}_0 = [1 \ x_0 \ x_0^2 \ \dots \ x_0^k]$
 \underline{x}_0' is the transpose of \underline{x}_0

and $\bar{y}(x_0)$ has been evaluated for x_0 using the estimated regression relation.

$t_{.95, \nu}$ is obtained with $\nu = n - k - 1$ degrees of freedom.

$$s = \sqrt{\frac{\sum_{i=1}^n (y_i - \bar{y}(x_i))^2}{n - k - 1}} \quad \text{is the estimate of } \sigma.$$

$\bar{y}(x_i)$ = effective perceived noise level calculated using the estimated regression relation and i th measured value of engine related parameter, x_i .

It is not recommended that polynomial orders in excess of $k = 2$ be used for certification purposes, unless there is a clear basis for such a model.

3. CONFIDENCE INTERVAL FOR STATIC TEST DERIVED NPD MAPS

When static test data are used in family certifications, NPD maps are formed by the linear combination of baseline flight regressions, baseline projected static regressions, and derivative projected static regressions in the form

$$EPNL_{DF} = EPNL_{BF} - EPNL_{BS} + EPNL_{DS}.$$

or using the notation adopted above

$$\bar{y}_{DF}(x_0) = \bar{y}_{BF}(x_0) - \bar{y}_{BS}(x_0) + \bar{y}_{DS}(x_0).$$

where subscript

We define the matrix \underline{A} such that $\underline{A} = \underline{X}' \underline{X}$
and \underline{A}^{-1} is the inverse of \underline{A} .

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5. ADEQUACY OF THE MODEL

5.1 Choice of Engine-Related Parameter

Every effort should be **made to** determine the most appropriate engine-related parameter **x**, which may be a combination of various simpler parameters.

5.2 Choice of Regression Model

Also, a polynomial regression model should not be used if it is expected that a simpler relationship **should be** postulated; **e.g.**,

$\mu = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3$ should not be used if it is expected that the relationship is of the form $\mu = \gamma_0 + \gamma_1 W$, where $W = x^2$ or $W = x^3$

Standard texts on multiple regression should be consulted and the data available should be examined to show the adequacy or otherwise of the model chosen.

6. REFERENCES

- (1) Kendall, M.G. and Stuart, A., The Advanced Theory of Statistics, Volumes 1 and 2, Hafner, New York, 1973.
- (2) Yule, G. U. and Kendall, M.G., An Introduction to the Theory of Statistics, 14th ed., Griffin, New York, 1950.
- (3) Walpole, R. E. and Myers R.H., Probability and Statistics for Engineers and Scientists. MacMillan, New York, 1972.
- (4) Cochran, W. G., "Approximate Significance Levels of the Behrens-Fisher Test", Biometrics, 20, 191-195, 1964.
- (5) Rose, D.M., and Scholz, F. W., Statistical Analysis of Cumulative Shipper-Receiver Data, NUREG/CR-2819, Division of Facility Operations, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, NRC FIN B1076, 1983.
- (6) Snedecor, G.W. and Cochran, W.G., Statistical Methods, 6th ed, The Iowa State University Press, Ames Iowa, 1968.

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APPENDIX 2IDENTIFICATION OF SPECTRAL IRREGULARITIES1.0 Introduction

Spectral irregularities which are not produced by aircraft noise sources may cause tone corrections to be generated when the procedures of Annex 16, Volume 1 paragraph 4.3 of Appendix 1 and 2, are used. These spectral irregularities may be caused by:-

- (a) the reflected sound energy from the ground plane beneath the microphone mounted at 1.2 m above it, interfering with the direct sound energy from the aircraft. The **re-enforcing** and destructive effects of this interference is strongest at lower frequencies, typically 100 Hz to 200 Hz and diminishes with increasing frequency. The local peaks in the 1/3 octave spectra of such signals are termed pseudotones. Above 800 Hz this interference effect is usually insufficient to generate a tone correction when the Annex 16, Volume 1 tone correction procedures is used.
- (b) small perturbations in the propagation of aircraft noise when **analysed** with 1/3 octave bandwidth filters.
- (c) the data processing adjustments and corrections such as the background noise correction method and the adjustment for atmospheric attenuation. In the case of the latter, the atmospheric attenuation coefficients (α) given in ARP866A ascribe α values at 4 KHz to the **centre** frequency of the 1/3 octave band whereas at 5 KHz the value of α is ascribed to the lower pass frequency of the 1/3 octave. This difference is sufficient in some cases to generate a tone correction.

The inclusion of a tone correction factor in the computation of **EPNL** accounts for the subjective response due to the presence of pronounced spectral irregularities. Tones generated by aircraft noise sources are those for which the application of tone correction factors are appropriate. Tone correction factors which result from spectral irregularities, i.e. false tones produced by any of the above causes may be disregarded. This Appendix describes methods which have been approved for detecting and removing the effects of such spectral irregularities. However, approval of the use of any of these methods remains with the certificating authority.

2.0 Methods for identifying false tones2.1 Frequency Tracking

Frequency tracking of flyover noise data is useful for the frequency tracking of spectral irregularities. The observed frequency of **aeroplane** noise sources decrease continuously during the flyover due to Doppler frequency shift, **f_{DOP}** where:-

$$f_{DOP} = \frac{f}{1 - M \cos \lambda}$$

where f is the frequency of the noise at source

M is the Mach number of the **aeroplane**

λ is the angle between the flight path in the direction of flight and a line connecting the source and observer at the time of emission.

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APPENDIX 3A PROCEDURE FOR REMOVING THE EFFECTS OF AMBIENT NOISE
LEVELS FROM AEROPLANE NOISE DATA1 Introduction

1.1 The following information is provided as guidance material for certificating authorities on the method of removing the effect of ambient noise on **aeroplane** recorded noise.

1.2 This is not the only procedure which may be used and changes under certain instances may be made to it, but approval for its use in its current or modified form remains with the certificating authority.

2 Correction Procedure

2.1 **Aeroplane** sound pressure levels within the **10 dB** down points should exceed the mean ambient noise levels determined above by at least **3 dB** in each one-third octave band or be corrected by the following or similar method.

- 1) The identification of the **predetection** and post-detection noise are made, i.e.:
 - a) one which adds to the recorded noise data on an energy basis, such as that from extraneous acoustic background noise signals is termed **pre-detection** noise;
 - b) one which is non-additive but masks the **aeroplane** noise signal such as would be produced by the lower level 'window' of the signal **analyser** is termed post-detection noise.
- 2) Over the frequency range of the **predetection** noise, the background noise is subtracted from the **analysed** noise on an energy basis.
 - i) at frequencies of **630 Hz** and below, if the **analysed** level is within **3 dB** of the background **predetection** noise level ('masked' band), the corrected **aeroplane** noise is set equal to the **predetection** background level. If the **analysed** level is less than the background level, no changes are made to this level.
 - ii) at frequencies above **630 Hz**, if the **analysed** level is within **3 dB** or less than the **predetection** noise level, these levels are also identified as 'masked' and are corrected as in Steps **4), 5) and 6).**
- 3) The remaining bands which fall inside the frequency range of the post-detection background noise are uncorrected unless they are within **3 dB** of the identified post-detection noise, these bands are thus identified as 'masked' bands.
- 4) The 'as measured' spectrum is **normalised** to reference day conditions (**25°C, 70% RH**) and a distance from source of **60 m**.
- 5) For the 'masked' high frequency bands at **60 m** a linear extrapolation from the next lower frequency unmasked band of **0 dB/one-third octave**, or a greater slope if derived from measured data, **is** applied.

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ATTACHMENT B TO THE REPORT ON AGENDA ITEM 3PROPOSED AMENDMENTS TO ANNEX 16, VOLUME I - RECOMMENDATION 3/51. PART II, CHAPTER 2

In paragraph 2.6.1.1 amend "Take-off thrust" to read "Average take-off thrust".

2. PART II, CHAPTER 3

a) Amend the title as follows:

- "1. SUBSONIC JET AEROPLANES - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR THE PROTOTYPE ACCEPTED ON OR AFTER 6 OCTOBER 1977
2. PROPELLER-DRIVEN AEROPLANES OVER 5 700 kg - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR THE PROTOTYPE ACCEPTED ON OR AFTER 1 JANUARY 1985 AND BEFORE (applicability date)
3. PROPELLER-DRIVEN AEROPLANES OVER 9 000 kg - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR THE PROTOTYPE ACCEPTED ON OR AFTER (applicability date)".

b) Amend paragraph 3.1.1 as follows:

"3.1.1 The Standards of this chapter shall be applicable to:

- a) all subsonic jet aeroplanes, including their derived versions, other than aeroplanes which require a runway* length of 610 m or less at maximum certificated mass for airworthiness, in respect of which either the application for certificate of airworthiness for the prototype was accepted or another equivalent prescribed procedure was carried out by the certificating authorities, on or after 6 October 1977;
- b) all propeller-driven aeroplanes, including their derived versions, of over 5 700 kg maximum certificated take-off mass (except those described in 6.1.1), for which either the application for certificate of airworthiness for the prototype was accepted or another equivalent prescribed procedure was carried out by the certificating authorities, on or after 1 January 1985 and before (applicability date);
- c) all propeller-driven aeroplanes, including their derived versions, of over 9 000 kg maximum certificated take-off mass, for which either the application for certificate of

airworthiness for the prototype was accepted or another equivalent prescribed procedure was carried out by the certificating authorities, on or after (applicability date)."

- c) In paragraph 3.6.2.1 a) amend "Take-off thrust" to read "Average take-off thrust/power";
- d) In paragraph 3.6.2.1 b) lines 2 and 7, amend "thrust" to read "thrust/power";
- e) In paragraph 3.6.3.1 b) amend "thrust" to read "thrust/power";
- f) Amend paragraph 3.6.3.1 e) to read as follows:
 - "e) the most critical (that which produces the highest noise level) configuration with normal deployment of aerodynamic control surfaces including lift and drag producing devices, at the mass at which certification is requested shall be used."

3. PART II, CHAPTER 5

- a) Amend the title to read as follows:

"PROPELLER-DRIVEN AEROPLANES OVER 5 700 kg - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR THE PROTOTYPE ACCEPTED ON OR AFTER 6 OCTOBER 1977 AND BEFORE 1 JANUARY 1985"; and

- b) in paragraph 5.6.2.1 a) amend "Take-off power" to read "Average take-off power".

4. TITLE OF APPENDIX 2

Amend the title to read as follows:

'APPENDIX 2. EVALUATION METHOD FOR NOISE CERTIFICATION OF

1. SUBSONIC JET AEROPLANES - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR THE PROTOTYPE ACCEPTED ON OR AFTER 6 OCTOBER 1977
2. PROPELLER-DRIVEN AEROPLANES OVER 5 700 kg - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR THE PROTOTYPE ACCEPTED ON OR AFTER 1 JANUARY 1985 AND BEFORE (applicability date)
3. PROPELLER-DRIVEN AEROPLANES OVER 9 000 kg - APPLICATION FOR CERTIFICATE OF AIRWORTHINESS FOR 'THE PROTOTYPE ACCEPTED ON AND AFTER (applicability date)

Note. - See Chapter 3, Part II."

airworthiness for the prototype was accepted or another equivalent prescribed procedure was carried out by the certificating authorities, on or after (applicability date)."

- c) In paragraph 3.6.2.1 a) amend "Take-off thrust!" to read "Average take-off thrust/power";
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Note. - See Chapter 3, Part II."

- f) wind speed not above 22 km/hr (12 kts) and cross-wind speed not above 13 km/hr (7 kts) at 10 m (33 ft) above ground over the 10 dB-down time interval.

Note 1.— These limits are based on the use of an anemometer with a built-in detector time constant of 30 seconds. For anemometers with shorter detector times the effects of short term gusts during the 10 dB-down period must be considered and in such instances the maximum value of gusts should not exceed 28 km/hr (15 kts) and a maximum average wind value of no more than 22 km/hr (12 kts). The maximum value of cross-wind gust should not exceed 18 km/hr (10 kts) and a maximum average cross-wind of 12 km/hr (7 kts).

Note 2.— The cross-wind component shall be based on the continuous windspeed vector resolution in the cross-wind direction;

- g) no anomalous wind conditions that would significantly affect the noise level of the aeroplane when the noise is recorded at the measuring points specified by the certificating authorities.

When a multiple layering calculation is required by paragraph 2.2.2 (e) the atmosphere between the aeroplane and 10 m above the ground shall be divided into layers of equal depth. The depth of the layers shall be determined by the minimum depth of the layer giving a variation of ± 0.5 dB/100 m in the atmospheric absorption coefficient of the 3150 Hz 1/3-octave band over any part of the noise propagation path with a minimum layer depth of 30 m. The mean of the values of the atmospheric absorption coefficients at the top and bottom of each layer may be used to characterize the absorption properties of each layer."

6. SECTION 7 OF APPENDIX 2

Replace the equation in 7.3 c) by the following:

$$n = 0.3 \text{ antilog}_{10} \{M(e) [SPL - SPL(e)]\}$$

7. SECTION 9 OF APPENDIX 2

- a) Delete paragraph 9.1.2;

- b) Replace existing paragraphs 9.1.3 and 9.1.4 by the following:

"9.1.2 Either the 'simplified' method or the 'integrated' method shall be used for flyover, approach, or lateral noise measurements when:

- a) the amounts of the adjustments are less than 8 dB on take-off, 4 dB on approach, and 4 dB on lateral; or
- b) the amounts of the adjustments on take-off are more than 4 dB and the resulting numbers are not within 1 dB of the limiting noise levels.

9.1.3 When the amounts of the adjustments or the corresponding margin are outside the limits specified in 9.1.2, the 'integrated' method shall be used for all noise measurement adjustments."

- c) Add the following to paragraph 9.2.2:

"The aeroplane reference point during approach measurements shall be the ILS antenna."

8. Removal of reference to ISO 3891-1978(E)

8.1 APPENDIX 1

Replace the existing text in 8 on the Sound Attenuation in Air by:

"8. Sound Attenuation in Air

8.1 The atmospheric attenuation of sound shall be determined in accordance with the procedure presented below.

8.2 The relationship between sound attenuation, frequency, temperature and humidity is expressed by the following equations:

$$\alpha_i = 10 \left(2.05 \log (f_0/1000) + 1.1394 \cdot 10^{-3} \theta - 1.916984 \right) + \eta(\delta) \times 10 \left(\log (f_0) + 8.42994 \cdot 10^{-3} \theta - 2.755624 \right) \text{ dB/100 m}$$

where

$$\delta = \sqrt{\frac{1010}{f_0}} \cdot 10 \left(\log H - 1.328924 + 3.179768 \cdot 10^{-2} \theta \right) \times 10 \left(-2.173716 \cdot 10^{-4} \theta^2 + 1.7496 \cdot 10^{-6} \theta^3 \right)$$

$\eta(\delta)$ is given by Table 1-5 and f_0 by Table 1-6;

α_i being the attenuation coefficient in dB/100 m;

- a) the amounts of the adjustments are less than 8 dB on take-off, 4 dB on approach, and 4 dB on lateral; or
- b) the amounts of the adjustments on take-off are more than 4 dB and the resulting numbers are not within 1 dB of the limiting noise levels.

9.1.3 When the amounts of the adjustments or the corresponding margin are outside the limits specified in 9.1.2, the 'integrated' method shall be used for all noise measurement adjustments."

- c) Add the following to paragraph 9.2.2:

"The aeroplane reference point during approach measurements shall be the ILS antenna."

8. Removal of reference to ISO 3891-1978(E)

8.1 APPENDIX 1

Replace the existing text in 8 on the Sound Attenuation in Air by:

"8. Sound Attenuation in Air

8.1 The atmospheric attenuation of sound shall be determined in accordance with the procedure presented below.

8.2 The relationship between sound attenuation, frequency, temperature and humidity is expressed by the following equations:

$$\alpha_i = 10 \left(2.05 \log (f_0/1000) + 1.1394 \cdot 10^{-3} \theta - 1.916984 \right) + \eta(\delta) \times 10 \left(\log (f_0) + 8.42994 \cdot 10^{-3} \theta - 2.755624 \right) \text{ dB/100 m}$$

where

$$\delta = \sqrt{\frac{1010}{f_0}} \cdot 10 \left(\log H - 1.328924 + 3.179768 \cdot 10^{-2} \theta \right) \times 10 \left(-2.173716 \cdot 10^{-4} \theta^2 + 1.7496 \cdot 10^{-6} \theta^3 \right)$$

$\eta(\delta)$ is given by Table 1-5 and f_0 by Table 1-6;

α_i being the attenuation coefficient in dB/100 m;

TABLE 1.7 - sound attenuation coefficient in dB/100 m

Band centre frequency	Relative humidity = 10%										
	Temperature, °C										
HZ	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
125	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.2
250	0.2	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2
315	0.2	0.4	0.5	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2
400	0.3	0.5	0.7	0.8	0.6	0.5	0.4	0.3	0.3	0.3	0.3
500	0.3	0.5	0.8	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.4
630	0.3	0.6	0.9	1.2	1.2	1.0	0.9	0.7	0.6	0.5	0.5
800	0.4	0.6	1.0	1.5	1.7	1.5	1.2	1.0	0.8	0.7	0.6
1000	0.4	0.7	1.2	1.8	2.1	2.0	1.7	1.4	1.2	1.0	0.9
1250	0.4	0.8	1.3	2.1	2.6	2.8	2.4	2.0	1.7	1.4	1.2
1600	0.5	0.9	1.4	2.3	3.3	3.8	3.4	2.9	2.4	2.0	1.7
2000	0.6	1.0	1.6	2.6	3.9	4.7	4.7	4.1	3.4	2.8	2.3
2500	0.7	1.1	1.8	2.9	4.5	5.8	6.4	5.6	4.8	4.0	3.3
3150	0.8	1.2	2.0	3.2	5.1	7.1	8.3	7.7	6.8	5.7	4.8
4000	0.9	1.4	2.3	3.6	5.7	8.5	10.5	11.0	9.6	8.3	6.9
5000	1.0	1.6	2.4	3.8	6.1	9.2	11.7	12.8	11.3	9.9	8.3
6300	1.3	1.9	2.8	4.3	6.8	10.4	14.2	16.4	15.5	13.7	11.7
8000	1.6	2.3	3.4	5.0	7.7	11.8	17.0	20.8	22.0	19.4	16.8
10000	2.1	2.9	4.1	6.0	8.9	13.4	19.9	25.9	29.5	27.2	24.1
12500	2.9	3.7	5.0	7.1	10.3	15.3	22.7	31.2	36.9	37.6	33.4

TABLE 1.8 - Sound attenuation coefficient in dB/100 m

Band centre frequency	Relative humidity = 20%										
	Temperature, °C										
Hz	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2
315	0.4	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
400	0.5	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.3
500	0.6	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.3	0.4
630	0.7	1.0	1.0	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5
800	0.8	1.2	1.4	1.2	0.9	0.7	0.6	0.5	0.5	0.6	0.6
1000	0.9	1.4	1.8	1.6	1.3	1.0	0.8	0.7	0.7	0.7	0.8
1250	0.9	1.6	2.2	2.2	1.8	1.5	1.2	1.0	0.9	0.9	1.0
1600	1.1	1.9	2.7	3.1	2.6	2.1	1.7	1.4	1.2	1.2	1.3
2000	1.2	2.0	3.2	3.9	3.6	3.0	2.5	2.0	1.7	1.5	1.6
2500	1.3	2.3	3.7	4.9	5.0	4.2	3.5	2.8	2.3	2.0	2.0
3150	1.5	2.5	4.2	6.0	6.8	5.8	4.9	4.0	3.3	2.8	2.7
4000	1.7	2.9	4.8	7.2	8.7	8.2	7.1	5.9	4.9	4.0	3.6
5000	1.9	3.1	5.1	7.9	9.8	9.7	8.4	7.0	5.9	4.8	4.2
6300	2.2	3.5	5.7	9.0	12.0	13.3	11.5	9.9	8.2	6.8	5.8
8000	2.7	4.1	6.5	10.4	14.8	17.4	16.2	14.1	12.0	10.0	8.3
10000	3.3	4.9	7.5	11.8	17.7	22.0	23.1	20.1	17.2	14.5	12.1
12500	4.1	5.9	8.8	13.4	20.5	27.1	30.6	27.5	24.2	20.6	17.4

TABLE 1.9 - sound attenuation coefficient in dB/100 m

Band centre frequency HZ	Relative humidity = 30%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2
400	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4
630	0.9	0.9	0.7	0.5	0.4	0.3	0.3	0.4	0.4	0.4	0.5
800	1.1	1.3	1.0	0.8	0.6	0.5	0.4	0.5	0.5	0.6	0.6
1000	1.3	1.6	1.4	1.1	0.9	0.7	0.6	0.6	0.6	0.7	0.8
1250	1.5	2.0	1.9	1.6	1.2	0.9	0.8	0.7	0.8	0.9	1.0
1600	1.7	2.5	2.7	2.2	1.8	1.4	1.1	1.0	1.0	1.1	1.3
2000	1.9	3.0	3.6	3.1	2.5	2.0	1.6	1.4	1.3	1.4	1.6
2500	2.1	3.5	4.4	4.2	3.5	2.8	2.2	1.9	1.7	1.8	2.0
3150	2.3	4.0	5.5	5.9	4.9	4.0	3.3	2.6	2.3	2.3	2.5
4000	2.6	4.5	6.8	7.9	6.9	5.8	4.7	3.8	3.3	3.1	3.3
5000	2.8	4.8	7.4	9.0	8.2	6.9	5.7	4.6	3.9	3.6	3.7
6300	3.2	5.3	8.6	11.1	11.3	9.6	8.0	6.6	5.4	4.8	4.7
8000	3.8	6.1	9.9	13.9	15.6	13.6	11.5	9.5	7.9	6.8	6.4
10000	4.5	7.1	11.4	16.9	20.3	19.1	16.6	13.9	11.6	9.7	8.8
12500	5.5	8.3	13.0	20.0	25.3	26.6	23.0	19.6	16.4	13.8	12.1

TABLE 1.10 - sound attenuation coefficient in dB/100 m

Band centre frequency HZ	Relative humidity = 40%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.6	0.5	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	1.2	1.0	0.8	0.6	0.4	0.4	0.4	0.5	0.5	0.6	0.6
1000	1.4	1.4	1.1	0.8	0.6	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.8	1.9	1.5	1.2	0.9	0.7	0.7	0.7	0.8	0.9	1.0
1600	2.1	2.6	2.1	1.7	1.3	1.0	0.9	0.9	1.0	1.1	1.3
2000	2.5	3.2	2.9	2.4	1.9	1.5	1.2	1.2	1.3	1.4	1.6
2500	2.8	4.0	4.1	3.3	2.6	2.1	1.7	1.6	1.7	1.8	2.0
3150	3.2	4.9	5.6	4.7	3.8	3.0	2.4	2.1	2.1	2.3	2.5
4000	3.6	5.9	7.2	6.5	5.4	4.3	3.5	3.0	2.8	3.0	3.3
5000	3.8	6.3	8.1	7.7	6.5	5.2	4.2	3.5	3.3	3.4	3.7
6300	4.3	7.2	10.0	10.7	9.0	7.3	6.0	4.9	4.4	4.3	4.7
8000	5.0	8.3	12.3	14.4	12.6	10.6	8.7	7.1	6.1	5.8	6.2
10000	5.8	9.5	14.8	18.4	17.8	15.2	12.7	10.5	8.8	8.1	8.1
12500	6.9	10.9	17.2	22.9	24.7	21.2	17.8	14.9	12.4	10.9	10.6

TABLE 1.9 - sound attenuation coefficient in dB/100 m

Band centre frequency HZ	Relative humidity = 30%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2
400	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4
630	0.9	0.9	0.7	0.5	0.4	0.3	0.3	0.4	0.4	0.4	0.5
800	1.1	1.3	1.0	0.8	0.6	0.5	0.4	0.5	0.5	0.6	0.6
1000	1.3	1.6	1.4	1.1	0.9	0.7	0.6	0.6	0.6	0.7	0.8
1250	1.5	2.0	1.9	1.6	1.2	0.9	0.8	0.7	0.8	0.9	1.0
1600	1.7	2.5	2.7	2.2	1.8	1.4	1.1	1.0	1.0	1.1	1.3
2000	1.9	3.0	3.6	3.1	2.5	2.0	1.6	1.4	1.3	1.4	1.6
2500	2.1	3.5	4.4	4.2	3.5	2.8	2.2	1.9	1.7	1.8	2.0
3150	2.3	4.0	5.5	5.9	4.9	4.0	3.3	2.6	2.3	2.3	2.5
4000	2.6	4.5	6.8	7.9	6.9	5.8	4.7	3.8	3.3	3.1	3.3
5000	2.8	4.8	7.4	9.0	8.2	6.9	5.7	4.6	3.9	3.6	3.7
6300	3.2	5.3	8.6	11.1	11.3	9.6	8.0	6.6	5.4	4.8	4.7
8000	3.8	6.1	9.9	13.9	15.6	13.6	11.5	9.5	7.9	6.8	6.4
10000	4.5	7.1	11.4	16.9	20.3	19.1	16.6	13.9	11.6	9.7	8.8
12500	5.5	8.3	13.0	20.0	25.3	26.6	23.0	19.6	16.4	13.8	12.1

TABLE 1.10 - sound attenuation coefficient in dB/100 m

Band centre frequency HZ	Relative humidity = 40%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.6	0.5	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	1.2	1.0	0.8	0.6	0.4	0.4	0.4	0.5	0.5	0.6	0.6
1000	1.4	1.4	1.1	0.8	0.6	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.8	1.9	1.5	1.2	0.9	0.7	0.7	0.7	0.8	0.9	1.0
1600	2.1	2.6	2.1	1.7	1.3	1.0	0.9	0.9	1.0	1.1	1.3
2000	2.5	3.2	2.9	2.4	1.9	1.5	1.2	1.2	1.3	1.4	1.6
2500	2.8	4.0	4.1	3.3	2.6	2.1	1.7	1.6	1.7	1.8	2.0
3150	3.2	4.9	5.6	4.7	3.8	3.0	2.4	2.1	2.1	2.3	2.5
4000	3.6	5.9	7.2	6.5	5.4	4.3	3.5	3.0	2.8	3.0	3.3
5000	3.8	6.3	8.1	7.7	6.5	5.2	4.2	3.5	3.3	3.4	3.7
6300	4.3	7.2	10.0	10.7	9.0	7.3	6.0	4.9	4.4	4.3	4.7
8000	5.0	8.3	12.3	14.4	12.6	10.6	8.7	7.1	6.1	5.8	6.2
10000	5.8	9.5	14.8	18.4	17.8	15.2	12.7	10.5	8.8	8.1	8.1
12500	6.9	10.9	17.2	22.9	24.7	21.2	17.8	14.9	12.4	10.9	10.6

TABLE 1.13 - sound attenuation coefficient in dB/100m

Band centre frequency	Relative humidity = 70%										
	Temperature, °C										
HZ	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2
315	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
630	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.8	0.6	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
1000	1.1	0.8	0.6	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.8
1250	1.5	1.1	0.9	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1600	2.1	1.7	1.2	0.9	0.8	0.8	0.9	1.0	1.0	1.1	1.3
2000	2.9	2.3	1.8	1.3	1.0	1.0	1.1	1.2	1.3	1.4	1.6
2500	3.7	3.2	2.5	1.9	1.5	1.3	1.4	1.5	1.7	1.8	2.0
3150	4.6	4.4	3.5	2.7	2.1	1.8	1.8	1.9	2.1	2.3	2.5
4000	5.7	6.3	5.1	4.0	3.1	2.5	2.3	2.5	2.7	3.0	3.3
5000	6.3	7.3	6.0	4.7	3.7	3.0	2.7	2.9	3.1	3.4	3.7
6300	7.5	9.3	8.2	6.6	5.2	4.2	3.6	3.6	4.0	4.3	4.7
8000	8.8	11.8	11.6	9.5	7.6	6.1	5.1	4.9	5.2	5.7	6.2
10000	10.2	14.8	16.4	13.7	11.1	9.0	7.4	6.8	6.8	7.4	8.1
12500	11.6	18.0	21.4	18.8	15.7	12.8	10.5	9.2	9.0	9.6	10.5

TABLE 1.14 - Sound attenuation coefficient in dB/100 m

Band centre frequency	Relative humidity = 80%										
	Temperature, °C										
HZ	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.5	0.3	0.3	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.7	0.5	0.4	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
1000	1.0	0.7	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.3	1.0	0.7	0.6	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1600	1.9	1.5	1.1	0.8	0.7	0.8	0.9	0.9	1.0	1.1	1.3
2000	2.6	2.0	1.5	1.1	1.0	1.0	1.1	1.2	1.3	1.4	1.6
2500	3.6	2.9	2.2	1.6	1.3	1.3	1.4	1.5	1.7	1.8	2.0
3150	4.7	4.0	3.1	2.4	1.9	1.7	1.8	1.9	2.1	2.3	2.5
4000	5.9	5.6	4.5	3.4	2.7	2.3	2.3	2.5	2.7	3.0	3.3
5000	6.6	6.6	5.3	4.1	3.2	2.7	2.6	2.8	3.1	3.4	3.7
6300	8.1	9.1	7.4	5.9	4.6	3.7	3.4	3.6	4.0	4.3	4.7
8000	9.8	12.0	10.4	8.4	6.7	5.4	4.8	4.8	5.2	5.7	6.2
10000	11.5	15.3	14.8	12.2	9.8	7.8	6.7	6.4	6.8	7.4	8.1
12500	13.3	18.9	20.5	17.0	13.9	11.3	9.4	8.7	8.9	9.6	10.5

TABLE 1.15 - Sound attenuation coefficient in dB/100 m

Band centre frequency Hz	Relative humidity = 90%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
1000	0.9	0.6	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.2	0.9	0.6	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1600	1.7	1.3	0.9	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3
2000	2.4	1.8	1.3	1.0	0.9	1.0	1.1	1.2	1.3	1.4	1.6
2500	3.3	2.6	1.9	1.4	1.2	1.3	1.4	1.5	1.7	1.8	2.0
3150	4.6	3.6	2.8	2.1	1.7	1.6	1.8	1.9	2.1	2.3	2.5
4000	6.0	5.1	4.0	3.0	2.4	2.2	2.3	2.5	2.7	3.0	3.3
5000	6.7	6.0	4.8	3.7	2.9	2.6	2.6	2.8	3.1	3.4	3.7
6300	8.3	8.3	6.7	5.2	4.0	3.4	3.3	3.6	4.0	4.3	4.7
8000	10.4	11.7	9.5	7.6	6.0	4.9	4.5	4.8	5.2	5.7	6.2
10000	12.6	15.4	13.5	11.0	8.8	7.1	6.3	6.3	6.8	7.4	8.1
12500	14.8	19.4	18.6	15.4	12.4	10.1	8.7	8.3	8.9	9.6	10.5

TABLE 1.16 - Sound attenuation coefficient in dB/100 m

Band centre frequency Hz	Relative humidity = 100%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
1000	0.8	0.6	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.1	0.8	0.6	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1600	1.6	1.2	0.8	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3
2000	2.2	1.6	1.2	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6
2500	3.0	2.3	1.7	1.3	1.2	1.3	1.4	1.5	1.7	1.8	2.0
3150	4.2	3.3	2.5	1.9	1.6	1.6	1.8	1.9	2.1	2.3	2.5
4000	5.9	4.7	3.6	2.7	2.2	2.1	2.3	2.5	2.7	3.0	3.3
5000	6.8	5.6	4.3	3.3	2.6	2.4	2.6	2.8	3.1	3.4	3.7
6300	8.5	7.6	6.0	4.7	3.7	3.3	3.3	3.6	4.0	4.3	4.7
8000	10.7	10.8	8.7	6.8	5.3	4.5	4.4	4.8	5.2	5.7	6.2
10000	13.3	15.1	12.5	10.0	7.9	6.5	6.0	6.3	6.8	7.4	8.1
12500	16.0	19.5	17.2	14.0	11.3	9.2	8.2	8.2	8.9	9.6	10.5

TABLE 1.15 - Sound attenuation coefficient in dB/100 m

Band centre frequency Hz	Relative humidity = 90%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
1000	0.9	0.6	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.2	0.9	0.6	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1600	1.7	1.3	0.9	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3
2000	2.4	1.8	1.3	1.0	0.9	1.0	1.1	1.2	1.3	1.4	1.6
2500	3.3	2.6	1.9	1.4	1.2	1.3	1.4	1.5	1.7	1.8	2.0
3150	4.6	3.6	2.8	2.1	1.7	1.6	1.8	1.9	2.1	2.3	2.5
4000	6.0	5.1	4.0	3.0	2.4	2.2	2.3	2.5	2.7	3.0	3.3
5000	6.7	6.0	4.8	3.7	2.9	2.6	2.6	2.8	3.1	3.4	3.7
6300	8.3	8.3	6.7	5.2	4.0	3.4	3.3	3.6	4.0	4.3	4.7
8000	10.4	11.7	9.5	7.6	6.0	4.9	4.5	4.8	5.2	5.7	6.2
10000	12.6	15.4	13.5	11.0	8.8	7.1	6.3	6.3	6.8	7.4	8.1
12500	14.8	19.4	18.6	15.4	12.4	10.1	8.7	8.3	8.9	9.6	10.5

TABLE 1.16 - Sound attenuation coefficient in dB/100 m

Band centre frequency Hz	Relative humidity = 100%										
	Temperature, °C										
	- 10	- 5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
1000	0.8	0.6	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8
1250	1.1	0.8	0.6	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1600	1.6	1.2	0.8	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3
2000	2.2	1.6	1.2	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6
2500	3.0	2.3	1.7	1.3	1.2	1.3	1.4	1.5	1.7	1.8	2.0
3150	4.2	3.3	2.5	1.9	1.6	1.6	1.8	1.9	2.1	2.3	2.5
4000	5.9	4.7	3.6	2.7	2.2	2.1	2.3	2.5	2.7	3.0	3.3
5000	6.8	5.6	4.3	3.3	2.6	2.4	2.6	2.8	3.1	3.4	3.7
6300	8.5	7.6	6.0	4.7	3.7	3.3	3.3	3.6	4.0	4.3	4.7
8000	10.7	10.8	8.7	6.8	5.3	4.5	4.4	4.8	5.2	5.7	6.2
10000	13.3	15.1	12.5	10.0	7.9	6.5	6.0	6.3	6.8	7.4	8.1
12500	16.0	19.5	17.2	14.0	11.3	9.2	8.2	8.2	8.9	9.6	10.5

ATTACHMENT C TO THE REPORT ON AGENDA ITEM 3RECOMMENDED METHOD FOR COMPUTING NOISE CONTOURS AROUND AIRPORTS1. Introduction

The noise at points on the ground from aeroplanes flying into and out of a nearby airport depends on a number of factors. Principal among these are the types of aeroplane and their powerplant; the power, flap and airspeed management procedures used on the aeroplanes themselves; the distances from the points concerned to the various flight paths; and local topography and weather, affecting sound propagation. Airport operations generally include different types of aeroplanes, various flight procedures and a range of operational weights. Because of the large quantity of aeroplane-specific data and airport operational information that would be required to compute the noise of each individual operation, it is customary in airport noise studies to make certain simplifications, leading to estimates of noise index values which are averages over long periods of time (typically several months). Calculations are usually repeated at each of a series of points around the airport and then interpolations are made to trace lines of equal noise index values (noise "contours") which are then used for study purposes.

In view of the large number of variables involved and the simplifications usually made in the calculations, it is desirable to recommend a single procedure for computing airport noise contours. The aim of this document is to provide an outline for such a recommended method, identifying the major aspects and supplying specifications in respect of each. An explanation of terms is given, covering those terms where confusion might arise. A complication is that the calculation method has to allow for the use of different noise descriptors as bases for national noise indices. Given this proviso, the method of calculation described should allow States to compute noise contours which are consistent with one another.

There are a number of noise-generating activities on operational airports which are excluded from the calculation procedures given here. These include use of thrust reversal by landing aeroplanes, taxiing, engine testing and use of auxiliary power-units. In practice, the effects of these activities are unlikely to affect the noise contours in regions beyond the airport boundary.

2. Scope

This document describes the major aspects of the calculation of noise contours for air traffic at an airport. It is primarily intended to be applied to civil, commercial airports, where the aeroplanes in operation are mostly either jet-engine powered or propeller-driven heavy types. If appropriate noise and performance data are available for propeller-driven light aeroplanes, then these types may also be included in the evaluation. Where the noise impact derives mostly from helicopters, however, this document is not applicable - the

ATTACHMENT C TO THE REPORT ON AGENDA ITEM 3RECOMMENDED METHOD FOR COMPUTING NOISE CONTOURS AROUND AIRPORTS1. Introduction

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6. Noise index

An expression used to rate noise in terms of subjective annoyance over a defined period of time; an index can incorporate weightings of the single-event levels according to the time of day or night at which they occur and/or a weighting of the number of events occurring within the time period. The time limits and weightings are chosen to conform with public opinion, as determined from surveys.

7. Flight path

The path of an aeroplane through the air, defined in three dimensions, usually with reference to an origin at the start of take-off roll or at the landing threshold.

8. Flight track (or ground track)

The vertical projection of the flight path onto the ground plane.

9. Flight profile

The elevation of the flight path, showing the variation of aeroplane height along the ground track.

10. Noise contour

A line of constant value of a noise index around an airport, due to the noise of a traffic mix of aeroplanes under normal operating conditions and using normal flight paths.

3.2

Symbols

a) Noise

L_A A-weighted sound pressure level

$L_{A\text{MAX}}$ maximum value of L_A

L_{AE} sound exposure level

L $L_{A\text{MAX}}$ or L_{AE} , under conditions identified by means of a subscript (see Section 6)

L_p 1/3-octave band sound pressure level

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T	ambient air temperature
p	ambient air pressure
ρ	ambient air density
θ	T/T_0
δ	P/P_0
σ	ρ/ρ_0 (also δ/θ)

d) Engine noise-related thrust parameters

E_ξ	thrust/noise constant
F_ξ	flight speed coefficient
G_ξ	altitude coefficient
H_ξ	temperature coefficient
C_{M_t}	propeller tip rotational Mach number coefficient
A_v	noise constant
B_v	thrust coefficient
c_v	speed-altitude coefficient
Y	second order engine speed coefficient
ξ	representation for parameters X_N/δ , $N/\sqrt{\theta}$, $SHP/\delta\sqrt{\theta}$ or N_p
$\Delta\xi$	difference in ξ due to temperature difference representing parameters $\Delta X_N/\delta$ or $\Delta SHP/\delta\sqrt{\theta}$
M_t	propeller tip rotational Mach number
N	low pressure rotor speed or fan speed
N_p	propeller rotational speed
SHP	engine shaft power
v	representation for parameters $N/\sqrt{\theta}$, $SHP/\delta\sqrt{\theta}$, EIS

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s	standard deviation
r	radial distance
ϕ	angle from the aeroplane ground track to a radial passing through an observation point
ψ	angle of turn of an aeroplane ground track

4. Calculation of the contours

4.1 Summary and applicability of the method

For an airport noise study, the calculations comprise the following, in order:

- a) determination of the noise levels from individual aeroplane movements at observation points around the airport;
- b) addition or combination of the individual noise levels at the respective points according to the formulation of the chosen noise index; and
- c) interpolation and plotting of contours of selected index values.

The numbers of aeroplane movements to be included in a study and the operational details for each are matters for selection. Clearly, a set of calculated noise contours is valid only for the traffic assumptions on which it is based. At all airports, the pattern of operations varies from day-to-day, depending on the weather, scheduling and many external factors. Generally the noise index for which the contours are calculated is defined in terms of long-term average daily values, typically over a period of some months. It follows that the contours intended to show noise exposures around an airport defined in terms of such an index should similarly depict long-term average conditions. The traffic and operational patterns used in the study are then selected accordingly.

The noise levels from individual movements are calculated (for given atmospheric conditions) from noise-power-distance and aeroplane performance data, see 5.2.5. The conditions for the noise data are defined by atmospheric attenuation rates, for which the yearly averages drawn from several major world airports are assumed. The performance data are for defined atmospheric temperature and humidity, airport altitude and wind speed. However, given that the calculated noise contours depict long-term averages, the same basic data are assumed to apply over specified ranges of conditions. The form of presentation, methods of derivation and reference conditions for the aeroplane data are given in Section 5.

The specification for noise data in Section 5 includes two noise descriptors. These are the maximum A-weighted sound pressure level occurring at some instant

during an aeroplane movement, and the sound exposure level, which is the level of an integral with time of the square of the A-weighted sound pressure during the aeroplane movement (see 5.1.2). The two descriptors selected are believed to be sufficient to permit the calculation of most noise indices in use within ICAO member States, either directly or with the use of empirical adjustments. The formulations for different noise indices are given in Appendix C to this document. The summation process for noise levels from individual aeroplane movements and interpolation of noise index values for contour plotting are computer-programming matters only and are left to the discretion of the user.

4.2 Input information requirements

For an airport noise study, the organization making the calculation will require the following information:

- a) the aeroplane types which operate from the airport;
- b) noise and performance data for each of the aeroplane types concerned, supplied in accordance with the specifications of Section 5 of this document:
- c) the routes followed by arriving and departing aeroplanes;
- d) the numbers of movements on each route within the period chosen for the calculations;
- e) the operational data and flight procedures relating to each route (including aeroplane masses, power settings, speeds and configurations during different flight segments); and
- f) airport data (including average meteorological conditions, number and alignment of runways).

4.3 Noise from individual aeroplane movements

For a movement on an arrival or departure route, aeroplane positional information and corrected engine thrusts are computed throughout the various flight operational segments (see Section 5). From a selected point (co-ordinates x, y) on a grid arranged on the ground around the airport (see Section 6) the shortest distance to the flight path is calculated and the noise data (L) are interpolated for the distance (d) and thrust (ξ) concerned. The aeroplane positional information should allow for some lateral displacement of the actual ground track in a particular case, relative to the nominal route, due to inexact track-keeping which occurs in practice. Corrections are applied (see also Section 6) for extra attenuation of sound during propagation lateral to the direction of aeroplane movement (A), for directivity behind the start of take-off ground roll (Δ_L) and (in the case of the sound exposure level) for aeroplane speed (Δ_V) and changes in the duration of the highest noise levels where an aeroplane makes a turn in its flight path (Δ_T). Hence the noise level at the

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Slant distance (m)	80	100	125	160	200	250	315	400	500	630	800
L_{AMAX} (dB)											
L_{AE} (dB)											

Slant distance (m)	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000
L_{AMAX} (dB)										
L_{AE} (dB)										

Note. - All noise levels are to be normalized to confirm with the attenuation rates of Table 1.

Figure 1. Format of noise data

The noise levels given should be those occurring directly under the flight path during steady flight (a constant speed of 160 knots, constant configuration and thrust setting, without banking). The aeroplane configuration and flight speed to which the noise levels correspond should be identified on the tables and graphs.

The physical quantity selected for the noise-related thrust parameter should be directly compatible with that presented in the performance information (see Section 5.2). Typical parameters are, amongst others, corrected net thrust, fan speed, propeller speed and engine shaft power.

In the noise tables, the intervals of the relevant parameters should be adequately spaced to ensure that the deviation from directly-obtained graph readings is less than a tenth of a decibel, assuming a linear interpolation. The number of thrust parameter values for which data are to be tabulated depends on the aeroplane type, but data must be provided at least for the approach and take-off values of the thrust parameter.

5.1.2 Noise descriptor

The noise data should be supplied in terms of the maximum A-weighted sound pressure level, L_{AMAX} , and the sound exposure level, L_{AE} .

Note.— The sound exposure level, L_{AE} , is defined (see ref 1) as follows:

$$L_{AE} = 10 \log \left\{ (1/t_0) \int_{t_1}^{t_2} (p_A^2(t)/p_0^2) dt \right\}$$

where $p(t)$ is the instantaneous A-weighted sound pressure, $(t_2 - t_1)$ is a stated time interval long enough to encompass all significant sound of a stated event, p_0 is the reference sound pressure (20 μ Pa) and t_0 is the reference duration (1s).

5.1.3 Noise data envelope

The envelope of the noise data should contain:

- a) a range of thrust-related noise parameter values which encompasses all the values likely to be selected on the aeroplane during flight operations at and in the vicinity of an airport; and
- b) perpendicular distances to the flight path ranging from 80 m to a maximum corresponding to a cut-off noise level of $L_{AMAX} = 65$ dB or $L_{AE} = 70$ dB.

5.1.4 Data derivation

Whenever possible the data should be based on the results of tests conducted under controlled conditions and should be comparable in quality to data acquired for aeroplane noise certification purposes (see ref 2). During controlled flyover noise tests, the position of the aeroplane along the flight path is measured and synchronized with the sound recordings. The aeroplane's engine power setting, flap deflection, landing gear setting, and airspeed are maintained at nominally constant values throughout the duration of each sound recording.

For the computation of L_{AMAX} and L_{AE} , measured aeroplane sound data are reduced to 1/3-octave band sound pressure levels in decibels relative to a reference pressure of 20 micropascals. Sound pressure levels are obtained, for the 24 1/3-octave bands with centre frequencies ranging from 50 Hz to 10 000 Hz, at 0.5 s intervals throughout the duration of each flyover sound recording. After correction for instrument calibrations and background noise contamination, the measured 1/3-octave band sound pressure levels are adjusted to conform with the attenuation rates of Table 1.

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TABLE 1. ATTENUATION RATES

Centre Frequency of 1/3-Octave Band (Hz)	Attenuation Rate (dB/100 m)
50	0.033
63	0.033
80	0.033
100	0.066
125	0.066
160	0.098
200	0.131
250	0.131
315	0.197
400	0.230
500	0.295
630	0.361
800	0.459
1000	0.590
1250	0.754
1600	0.983
2000	1.311
2500	1.705
3150	2.295
4000	3.115
5000	3.607
6300	5.246
8000	7.213
10000	9.836

a) Type 1 data - full spectral time history

1. Adjust measured data to conform with the attenuation rates of Table 1.
2. For source to observation distances of 800 m or less, establish noise-power-distance relationships at selected distances (see, for example, Figure 1) by extrapolation of the full time history pattern to obtain $L_{A\text{MAX}}$ and by performing time integration to obtain sound exposure level, L_{AE} (the "integrated" method of adjusting data, see Appendix 2, Section 9.4, of ref 2). The atmospheric attenuation rates of Table 1 are used as reference.

3. For a distance of 800 m define the sound exposure level, L_{AER} , the maximum value of A-weighted sound pressure level, L_{AMAXr} , and the 24 1/3-octave band sound pressure levels, $L_{pr i}$ (for $i = 1$ to 24) and the acoustic emission angle, corresponding to L_{AMAXr} .
4. For distances, d , greater than 800 m, compute L_{AMAX} for the adjusted spectral data, using the 800 m data as reference, by accounting for spherical divergence and atmospheric attenuation according to Table 1. L_{AE} for the new distance is determined by adding a 7.5 dB/decade duration factor for distance according to the following relation:

$$L_{AE} = L_{AMAX} + (L_{AER} - L_{AMAXr}) + 7.5 \log (d/800) \quad \text{Eq 2}$$

Note. - The above procedure is illustrated in Figure 2.

b) Type 2 data - spectrum at L_{AMAX} plus measured L_{AE}

1. Adjust measured spectral data corresponding to L_{AMAX} to conform with the attenuation rates of Table 1.
2. For the measurement distance define the sound exposure level, L_{AER} , the maximum value of A-weighted sound pressure level, L_{AMAXr} , and the 1/3-octave band sound pressure levels and the acoustic emission angle corresponding to L_{AMAXr} . The reference sound exposure level, L_{AER} , is derived from the test day L_{AE} adjusted by the incremental difference between L_{AMAX} corrected to the reference atmosphere and test day L_{AMAXr} ; i.e. L_{AER} for the measurement distance = $L_{AE} + (L_{AMAXr} - L_{AMAX})$.
3. For distances, d , other than the measurement distance d_r , compute L_{AMAX} for the adjusted spectral data by accounting for spherical divergence and atmospheric attenuation according to Table 1. L_{AE} for the new distance is determined from the following relation:

$$L_{AE} = L_{AMAX} + (L_{AER} - L_{AMAXr}) + 7.5 \log (d/d_r) \quad \text{Eq 3}$$

Note. - The above procedure is illustrated in Figure 3.

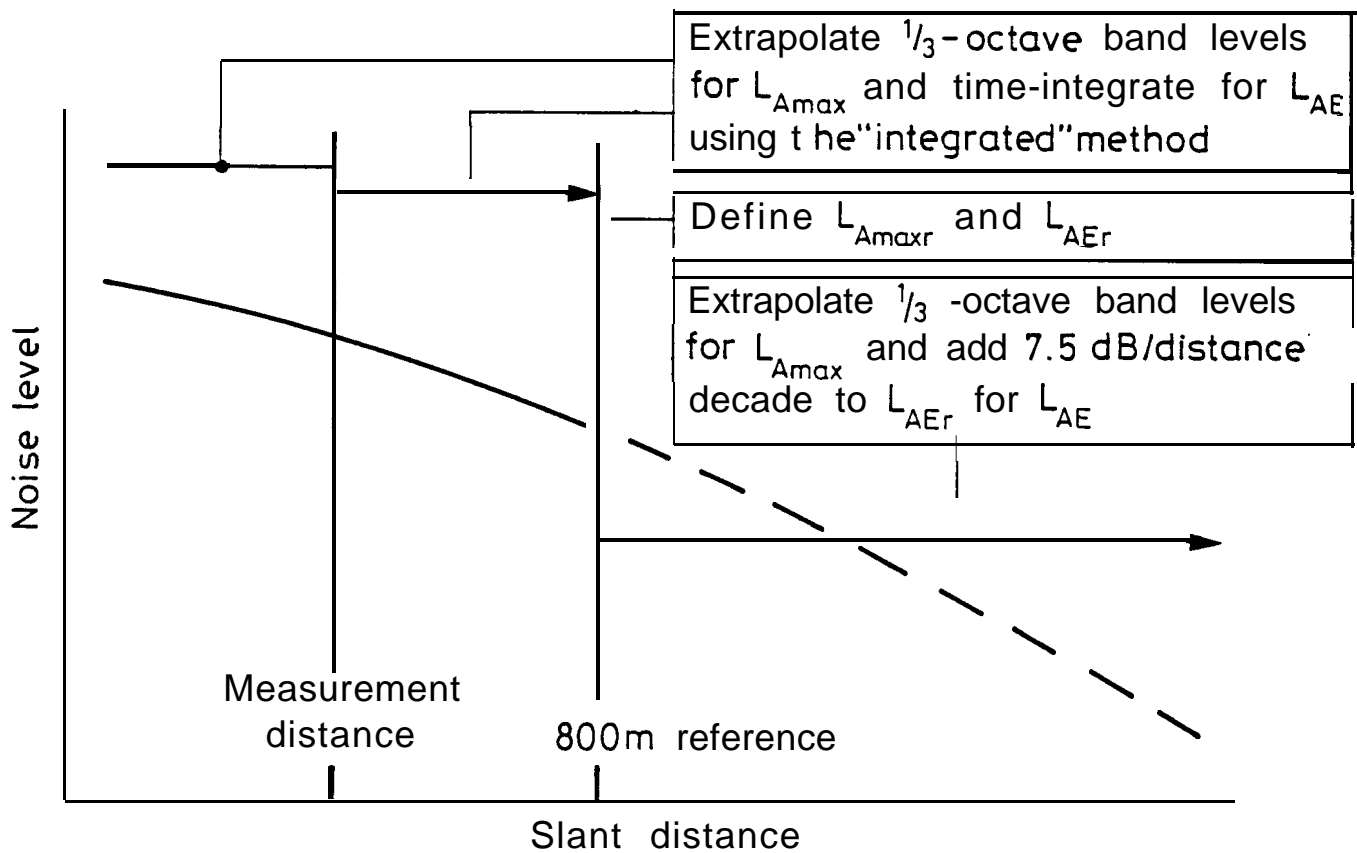


Figure 2. **Development** of noise-versus-distance data from Type 1 measurements (attenuation rates from Table 1 throughout)

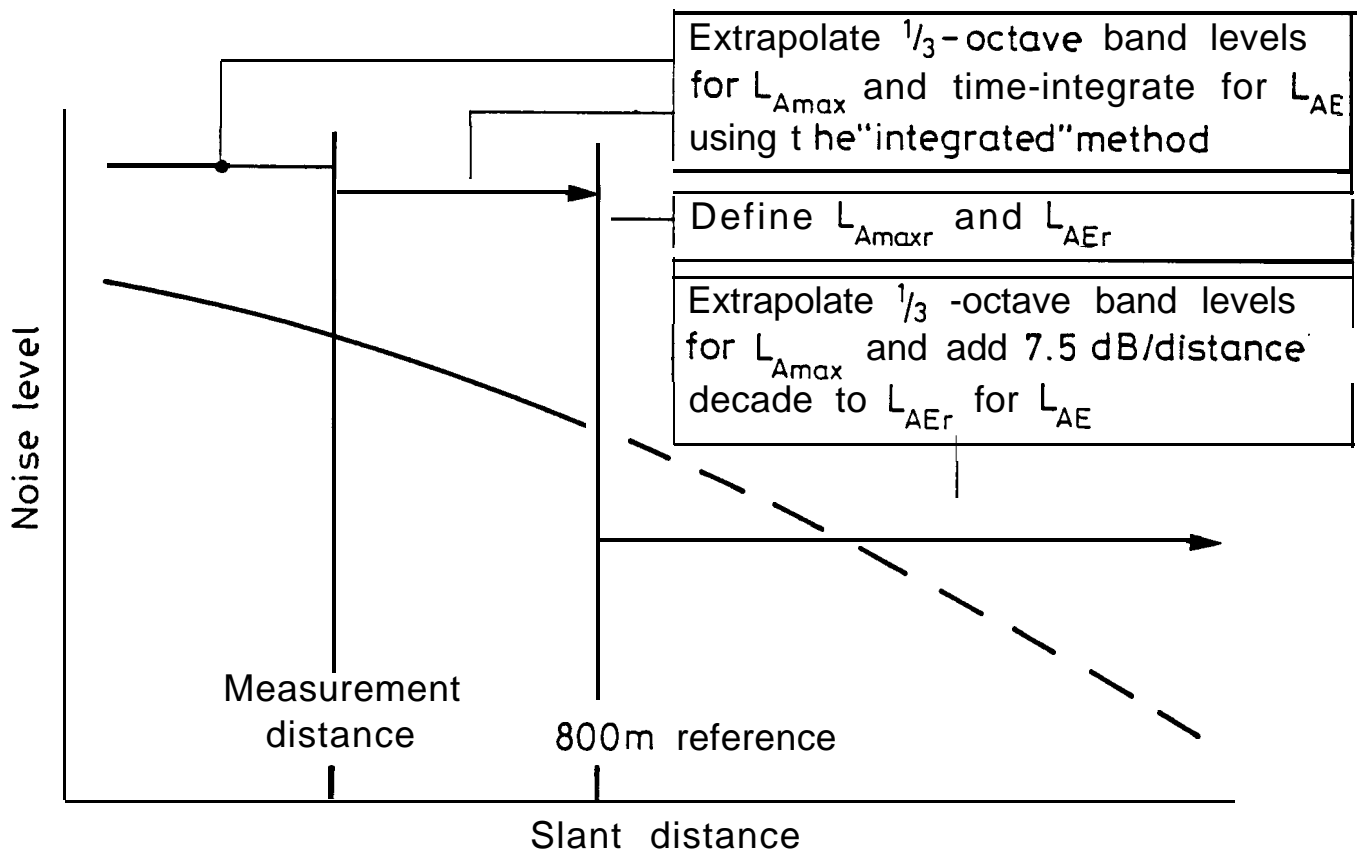


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Wind speed less than 8 m/s (15 knots)

The acceptable envelope for average local conditions defined above is believed to encompass conditions encountered at most of the world's major airports. For situations where average local conditions fall outside the noted envelope, it is suggested that the relevant aeroplane manufacturers should be consulted.

5.2 Performance data

5.2.1 Form of presentation

Aeroplane flight profiles are required in order to allow the determination of slant distances from the observation points to the flight paths. The variations of engine thrust (or other noise-related thrust parameter, see 5.1) and aeroplane speed along the flight path are also required. The slant distances and thrusts are then used for entry into and interpolation of the noise-power-distance data. For purposes of noise contour computations, take-off and approach flight paths are assumed to be represented by a series of straight-line segments, as illustrated in Figure 4. The ground tracks of the aeroplane are also represented by straight-line segments and arcs of circles,

Flight profiles, engine thrusts and aeroplane flight speeds might be supplied directly, for an aeroplane type undergoing reference flight procedures (see 5.2.2). Then for operations at an airport where the actual procedures in use are unknown, these reference procedures can be assumed. The information for other procedures known to be used, or for different operating conditions of the aeroplane, can be calculated using aerodynamic and thrust equations. The equations contain coefficients and constants which should also be made available for each combination of engine and aeroplane (see 5.2.3). The equations themselves are set out in Appendix A.

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- Take-off coefficient, P
- Flight speed coefficient, Q
- Climb/descent coefficient, R

The coefficients relating the relevant thrust/noise parameter for a specific power setting (representing a stated engine performance such as "take-off power" or "normal climb power") to flight speed, altitude and ambient temperature, are as follows:

- Thrust/noise constant, E_{ξ}
- Flight speed coefficient, F_{ξ}
- Altitude coefficient, G_{ξ}
- Temperature coefficient, H_{ξ}
- Propeller-tip Mach-number coefficient, CM_t

The subscript ξ above represents whichever engine noise-related corrected thrust parameter (X_N/δ , $N/\sqrt{\theta}$, $SHP/\delta\sqrt{\theta}$ or M_t) that might be appropriate to a particular case.

Further thrust/noise coefficients can be used, to establish the relation between thrust parameter and noise at "general" thrust settings, or the relationship between thrust and indicator setting, as follows:

- Noise constant, A_v
- Thrust coefficient, B_v
- Speed/altitude coefficient, C_v

The subscript v above represents either of the corrected engine parameters $N/\sqrt{\theta}$ or $SHP/\delta\sqrt{\theta}$ or an engine indicator setting (such as EPR or EPD). The derivation of these coefficients for an aeroplane type is discussed below, see 5.2.4.

5.2.4 Derivation of coefficients

The aeroplane performance coefficients, P, Q and R, the thrust coefficients for typical power settings, E_{ξ} , F_{ξ} , G_{ξ} and H and those for non-typical power settings, A_v , B_v and C_v , have to be evaluated for each model of an aeroplane, generally by the manufacturer. The evaluations should be performed for the reference conditions specified below in 5.2.5. The procedure will

- Take-off coefficient, P
- Flight speed coefficient, Q
- Climb/descent coefficient, R

The coefficients relating the relevant thrust/noise parameter for a specific power setting (representing a stated engine performance such as "take-off power" or "normal climb power") to flight speed, altitude and ambient temperature, are as follows:

- Thrust/noise constant, E_{ξ}
- Flight speed coefficient, F_{ξ}
- Altitude coefficient, G_{ξ}
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Wind speed less than 8 m/s

All practical operational aeroplane masses.

6. Calculation of the noise from individual aeroplane movements

6.1 Calculation grid

The noise contours are obtained by interpolation of discrete values of the noise index, resulting from a given traffic pattern, at the intersection points of an observation grid centred on the airport. The choice of spacing of the grid points determines the extent to which fluctuations of the noise index are taken into account. This is especially important where sharp changes occur in the noise contours (see circled areas in Figure 5).

Interpolation errors are minimized by a close grid spacing, but the cost of computer running time is increased through the greater number of points to be covered. A maximum value of about 300 m (1 000 ft) for the grid spacing constitutes a good compromise. This maximum value will ensure, in addition to a level of accuracy (standard deviation less than 0.5 dB for low- and medium-noise contours), good comparability in the results of the contour plotting, even when linear interpolation between the discrete noise index values is used to locate the contours.

For specific needs or for the plotting of noise contours located in zones close to the runways and the flight paths (see Figure 5) small values of the grid spacing should be chosen in order to obtain the desired level of accuracy.

6.2 Modelling of lateral dispersion across nominal ground tracks

6.2.1 Use of measurements

Noise contours calculated on the assumption that all aeroplane departure ground tracks follow exactly the nominal routes may be liable to localized errors, due to the effects of the dispersion which occurs in practice. It is recommended that, for greatest reliability, the forms and parameters of the distributions of departure and arrival departure ground tracks should be measured on each route at particular airports.

Wind speed less than 8 m/s

All practical operational aeroplane masses.

6. Calculation of the noise from individual aeroplane movements

6.1 Calculation grid

The noise contours are obtained by interpolation of discrete values of the noise index, resulting from a given traffic pattern, at the intersection points of an observation grid centred on the airport. The choice of spacing of the grid points determines the extent to which fluctuations of the noise index are taken into account. This is especially important where sharp changes occur in the noise contours (see circled areas in Figure 5).

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In these expressions, $s(y)$ is the standard deviation and x is the distance from start of roll. All distances are expressed in kilometres. In both cases, linear interpolation can be used to determine the standard deviation between the lift-off point (where $s(y) = 0$) and $x = 5$ km. Routes involving more than one turn should be treated using Eq 5. For arrivals, lateral dispersion can be neglected within 6 km of touchdown. Otherwise dispersion depends upon each individual runway and aeroplane type.

If substantial vectoring by air traffic control occurs for departures or arrivals, much larger dispersions should be assumed. For vectored departing aeroplanes, standard deviations are typically twice those for non-vectored aircraft.

Calculated values of noise indices are not particularly sensitive to the shape of the lateral distribution. The Gaussian form gives the best fit to many observed distributions. Although continuous distributions can be simulated, an approximate model is preferable on grounds of computing cost. As a minimum a 5-point discrete approximation should be used. The accuracy of the 5-point discrete approximation given in Table 2 generally gives values within 1 dB of those obtained from a continuous (Gaussian) distribution, and is recommended.

TABLE 2

PROPORTION OF AEROPLANES TO BE ASSUMED FOLLOWING DIFFERENT GROUND TRACKS SPACED ABOUT A NOMINAL TRACK (Y_m = mean track or nominal track as appropriate, and $s(y)$ = standard deviation).

Spacing	Proportion
$Y_m - 2.0 s(y)$	0.065
$Y_m - 1.0 s(y)$	0.24
Y_m	0.39
$Y_m + 1.0 s(y)$	0.24
$Y_m + 2.0 s(y)$	0.065

6.3 Determination of the shortest distance to the flight path

The next step in the calculations is to determine the respective distances from the grid points to the aeroplane flight paths. The symbols used to represent the different distances and angles are shown in Figure 6. The perpendicular distance from an observation-grid point, J , to the flight path (the slant distance or range) is given by:

$$d = \sqrt{\ell^2 + h^2 \cos^2 \gamma}$$

Eq 6

where ℓ is the perpendicular distance from the point to the ground track, h is the aeroplane height as it flies over the intersection of the perpendicular to the ground track, and γ is the climb angle of the flight path.

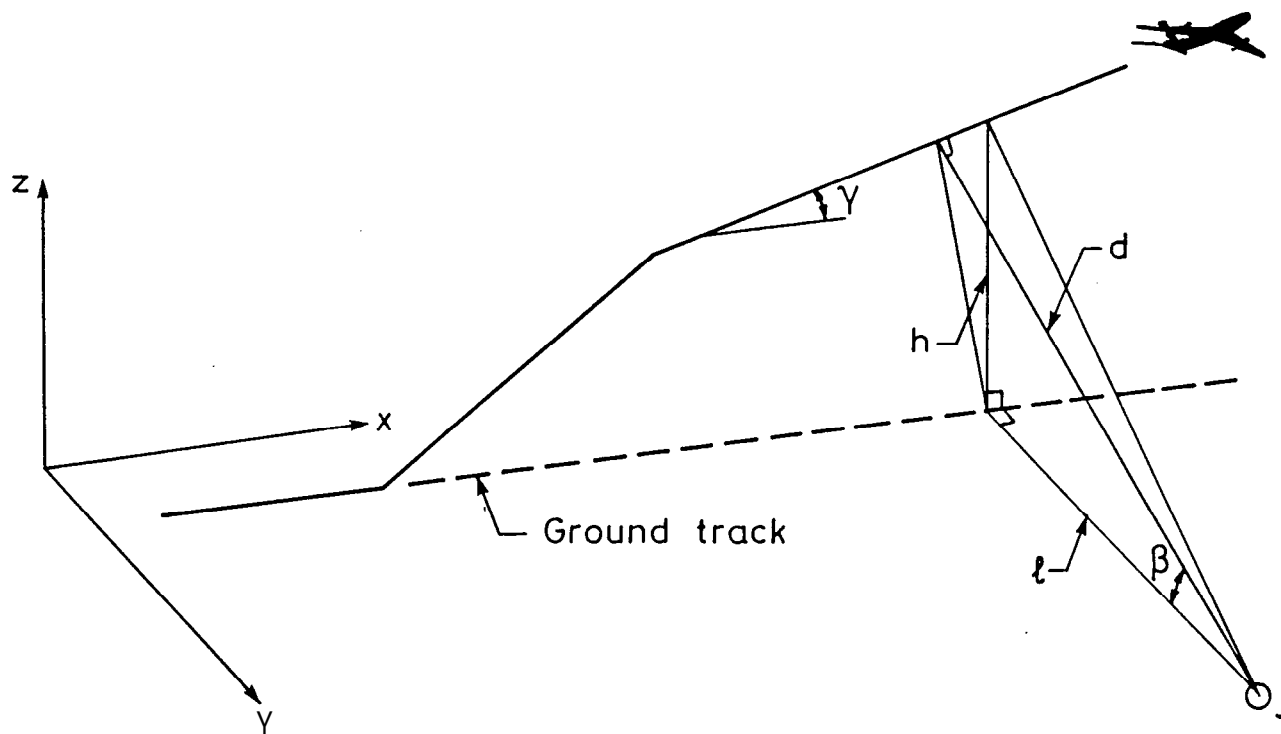


Figure 6. Identification of the distances and angles used for calculation of the noise from an aeroplane fly-past.

6.4

Interpolation of the noise-power-distance data

The noise-power-distance data described in Chapter 5 apply to an aeroplane in straight and level flight with a constant power-setting and reference speed. In operation at an airport the aeroplane may be climbing or descending during the flight segments of interest. However, it is assumed that the noise-versus-distance data still properly estimate L_{AMAX} or L_{AE} , if the shortest distance to the flight path is considered and the corresponding power-setting and velocity used.

As the tabulated noise-power-distance data points will not normally correspond to the actual power-setting and/or the actual shortest distance relevant to an observation point, it will generally be necessary to estimate the sound level or sound exposure level by interpolation. A linear interpolation is used between tabulated power-settings, whereas a logarithmic interpolation is used between tabulated distances, see Figure 7.

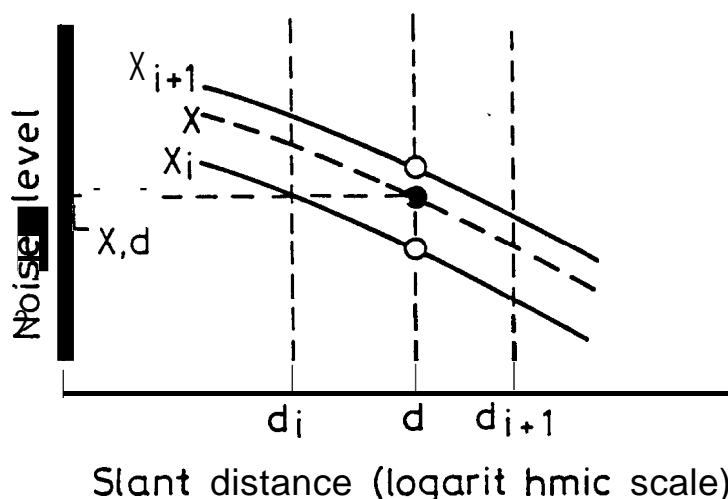


Figure 7. Noise-power-distance curves

Let X_i and X_{i+1} be tabulated net thrust values for which noise data are provided at some distance. The noise level (L_{AMAX} or L_{AE}) at the same distance for intermediate thrust X , between X_i and X_{i+1} , is given by:

$$L_X = L_{X_i} + (L_{X_{i+1}} - L_{X_i}) \left(\frac{(X - X_i)}{(X_{i+1} - X_i)} \right) \quad \text{Eq 7}$$

Let d_i and d_{i+1} be tabulated slant distances for which noise data are provided at some power-setting. The noise level (L_{AMAX} or L_{AE}) at the same net thrust for an intermediate distance d , between d_i and d_{i+1} , is given by:

$$L_d = L_{d_i} + (L_{d_{i+1}} - L_{d_i}) \left(\frac{(\log d - \log d_i)}{(\log d_{i+1} - \log d_i)} \right) \quad \text{Eq 8}$$

By using Eqs 7 and 8, a noise level $L_{X,d}$ can be obtained for any net thrust X and any distance d that is within the envelope of the reference data base, i.e. use of Eq 7 at d_i and d_{i+1} gives the levels at thrust X , at d_i and d_{i+1} , for use in Eq 8.

The noise levels at certain points on the observation grid will be affected by changes of engine power-setting on the aeroplane. In practice these do not occur instantaneously at the end of individual flight segments, but unless allowance is made in the computations for the smoothness of the aeroplane operation, unrealistic discontinuities are liable to appear in the noise contours. Suitable methods of including allowance for this effect are (i) the definition of a series of short profile segments with small incremental changes in thrust, and (ii) inclusion of a smoothing algorithm in the computer program for contour plotting.

6.5 Correction to the sound exposure level for aeroplane speed

Where L_{AE} data are presented, a correction will be necessary where the aeroplane speed differs from the reference speed of 160 knots for which the

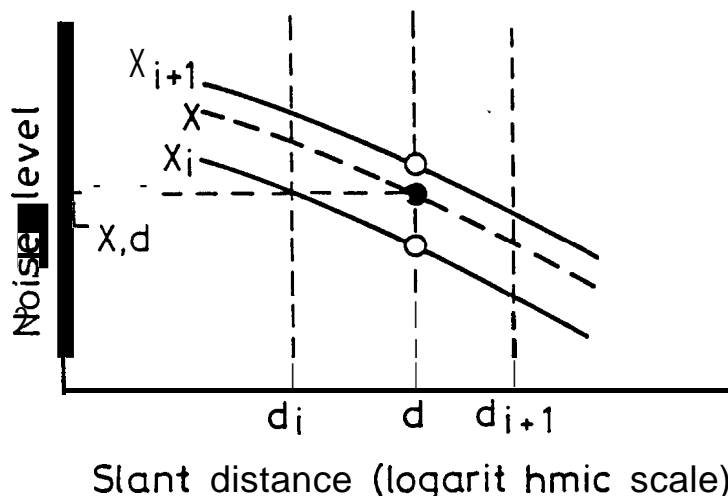


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6.5 Correction to the sound exposure level for aeroplane speed

Where L_{AE} data are presented, a correction will be necessary where the aeroplane speed differs from the reference speed of 160 knots for which the

$$\Lambda(\beta, \ell) = (G(\ell))(\Lambda(\beta))/13.86 \quad \text{Eq 14}$$

where $G(R)$ and $\Lambda(\beta)$ are given by Eqs 10 to 13.

Note.— Eqs 10 to 14 were developed using data from jet-propelled aeroplanes. In the case of propeller-driven aeroplanes, they might be subject to error.

6.7 Noise during the take-off roll

Modelling of the noise at ground positions near the airport runway during the take-off roll requires several modifications of the basic **noise-power-distance** data. The **modifications** result from the fact that the **aeroplane** is On the ground accelerating from essentially zero velocity to its initial climb speed, whereas the basic data are representative of overflight operations at constant airspeed. To accommodate these differences, consideration must be given to changes in generated sound resulting from jet relative-velocity effects, varying **directivity** patterns from the moving **aeroplane**, the modified effective duration with increased speed and extra attenuation of sound during over-ground propagation at near-zero elevation angles. As yet, insufficient data are available to allow all these effects to be taken fully into account. The present model is applicable to jet **aeroplanes** and is subject to further development in the light of continuing research. It may be used for propeller-driven **aeroplanes** until improved methods are developed.

Several factors can affect the accuracy of the **modelling**. Principal among these are wind and temperature gradients and variability in the operational procedures employed during take-off. The present model does not include any allowance for wind and temperature effects, even though these can cause significant changes in ground-to-ground attenuation and can even result in shadow zones in special cases. Experience has shown that different pilot techniques are employed at the start of the take-off roll, including a rolling start with no pause after taxiing, an early or a later selection of full take-off power, or even on occasion the application of full power while the brakes are still on. Noise contour calculations are intended to determine averages from a number of operations and so a method is given which is intended to encompass a combination of all these effects.

The method of **modelling** described below was developed from measurements of the sound exposure level, L_{AE} . However, it is believed from limited available experimental data that the method is applicable also in the case of the maximum sound pressure level, L_{AMAX} .

6.7.1 Take-off roll noise modelling for jet aeroplanes

Using the co-ordinate system of Figure 8, the noise level behind the start-of-roll point is computed as follows:

- a) The radial distance, r , from the start-of-roll position of the aeroplane to an observation point, K , and the angle ϕ in degrees between the radius to K and the runway axis, are determined.
- b) A directivity function, Δ_L , for the region behind the start-of-roll is evaluated as follows (ϕ expressed in degrees):

For $90^\circ \leq \phi < 148.4^\circ$

$$\Delta_L = 51.44 - 1.553\phi + 0.015147\phi^2 - 0.000047173\phi^3 \quad \text{Eq 15}$$

For $148.4^\circ \leq \phi \leq 180^\circ$

$$\Delta_L = 339.18 - 2.5802\phi - 0.0045545\phi^2 + 0.000044193\phi^3 \quad \text{Eq 16}$$

- c) The noise level at K , L_K , is then determined as follows:

$$L_K = L_{X_{T0}} + \Delta_V - G(r) + \Delta_L \quad \text{Eq 17}$$

where $L_{X_{T0}}$ is the noise level corresponding to distance r and net thrust X_{T0} (at lift-off from the runway) interpolated from the noise-power-distance data, Δ_V is a correction for the difference between a notional 32-knot speed near the start-of-roll and the reference airspeed for which the noise-power-distance data are quoted, $G(r)$ is the lateral attenuation adjustment corresponding to distance r (see 6.6), and Δ_L is the directivity factor determined from Eq 15 or 16 as appropriate.

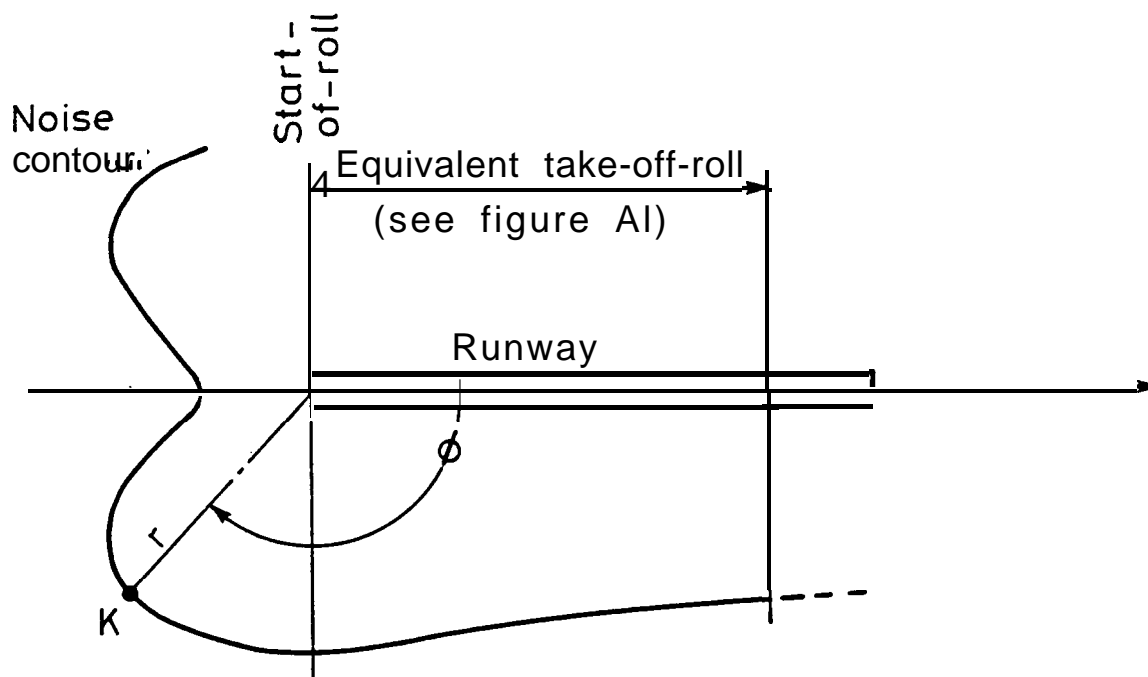


Figure 8. Geometry for construction of take-off roll noise contours

The noise levels after brake-release, at y-values to the side of the runway during the take-off roll, are also given by Eq 17 except that in this case $\Delta_L = 0$.

Notes:

1. Eq 17 applies to the L_{AE} noise descriptor. In the case of the L_{AMAX} descriptor the same formula applies, except that in that case $\Delta_V = 0$.
2. The correction to L_{AE} for aeroplane speed calculated at points to the side of the runway is to be determined on the assumption of constant aeroplane acceleration, from a typical minimum speed of 32 knots to the lift-off speed.

6.8 Correction to the sound exposure level at an observation point opposite a turn in the aeroplane flight track

The sound exposure level (see 5.1.2) includes an integral over time of the square of the instantaneous A-weighted sound pressure. The time limits of integration are such as to encompass all significant sound of a stated event (an aeroplane fly-past). "All significant sound" is usually interpreted to mean sound of levels within 10 dB of the maximum during the fly-past. The noise-power-distance data as described in Section 5 are for aeroplanes in straight and level flight.

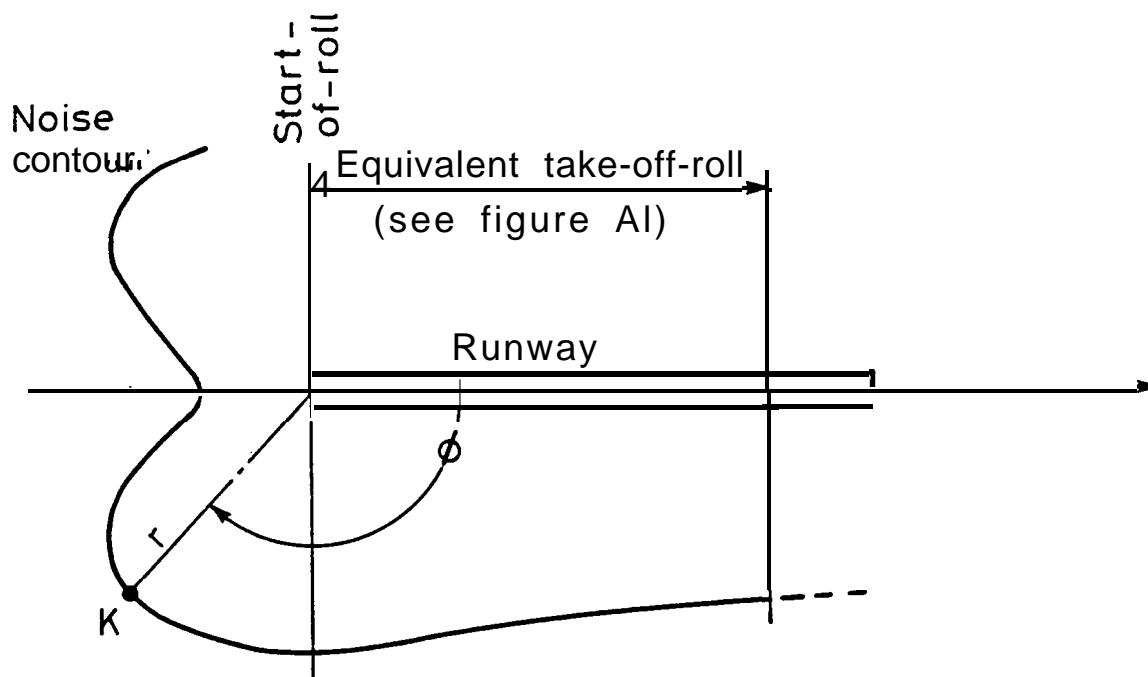


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7. References

1. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. 1982. Acoustics - Description and Measurement of Environmental Noise - Part 1: Basic Quantities and Procedures. ISO 1996/1 - 1982.
2. INTERNATIONAL CIVIL AVIATION ORGANIZATION. 1981. Annex 16 to the Convention on International Civil Aviation: Environmental Protection - Volume I, Aircraft Noise.
3. INTERNATIONAL CIVIL AVIATION ORGANIZATION. 1982. Procedures for Air Navigation Services - Aircraft Operations: Volume I, Flight Procedures. Part V - Noise Abatement Procedures, pages 5-4 to 5-7. Doc 8168-OPS/611, Volume I, Amendment 2, 1983.
4. SOCIETY OF AUTOMOTIVE ENGINEERS. 1981. Prediction Method for Lateral Attenuation of Airplane Noise During Take-off and Landing. Aerospace Information Report AIR 1751.

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that F_N and G_N are zero (see Eq A1). This assumption is valid for most turboprop engines.

A.1.2 General thrust settings

For a "general" thrust setting, e.g., during the approach or at cutback during the climb, the relation between the thrust and the thrust parameters is given by the following formula, in which v represents the thrust parameters $N/\sqrt{\theta}$ and $SHP/\delta\sqrt{\theta}$:

$$v = A_v + B_v(X_N/\delta) + C_v\{v_{EAS}(1 + 6.0 \times 10^{-5} h_p)\} \quad \text{Eq A6}$$

Where v represents $N/\sqrt{\theta}$, a more precise approximation would be obtained if a second-order term is introduced, i.e. v then becomes $(N/\sqrt{\theta} + Y(N/\sqrt{\theta})^2)$.

Note. - Eq A6 is unsuitable to determine the propeller rotational speed, N_p . For the approach, N_p is assumed constant (and equal to the reference N_p).

If a general thrust setting is defined by an engine indicator setting EIS (such as EPR , EPD or fan speed) the associated thrust can be obtained through Eq A6 by allowing v to represent the EIS . When an indicator setting represents an engine speed, the Note following Eq A6 applies.

The effect of de-rated (flexible) take-off thrust can be taken into account by reducing the coefficient E_X/δ in Eq A1 by an amount determined as follows:

$$\Delta E_{X_N}/\delta = (\Delta E_N/\sqrt{\theta}) / (B_N/\sqrt{\theta}) \quad \text{Eq A7}$$

where the coefficient $B_N/\sqrt{\theta}$ is obtained from Eq A6.

A.2 Flight profile and flight speeds

A.2.1 Equivalent take-off roll

The equivalent take-off roll, S_g , is the distance along the runway from the start of the take-off roll to the intersection point of the runway and the initial climb path projected downwards, see Figure A1.

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where σ is the ratio of ambient air density to the ISA sea-level value.

A.2.3 Climb (descent) angle

The climb (descent) angle of the flight path is determined as follows:

$$Y = \sin^{-1} \{ (f/f_w)(\bar{X}_N/W) - R \} \quad \text{Eq A12}$$

where f_w is the wind coefficient (Eq A9), R is the climb/descent performance coefficient (see 5.2.3) and f is an acceleration coefficient over the flight-path segment, as follows:

For an accelerated climb from position 1 to 2

$$1/f = 1 + (V_{TAS2}^2 - V_{TAS1}^2)/(2g(\Delta h)) \quad \text{Eq A13}$$

For a climb at constant V_{EAS} expressed in m/s

$$1/f = 1 + 5.2 \times 10^{-6} V_{EAS}^2 \quad \text{Eq A14}$$

The angle Y takes a positive value during the climb and a negative one during descent.

For a flap-retraction segment, the climb angle should be approximated by the average of the values of the coefficient R at the beginning and end of the segment.

If a rate of climb (RC) is given, the climb angle becomes

$$Y = \sin^{-1} \{ (RC)/(V_{TAS}(f_w)) \} \quad \text{Eq A15}$$

If a constant attitude is specified, the climb angle should be assumed constant for the purpose of flight-path schematization.

A.2.4 Horizontal distance covered in a flight segment

During climb or descent, the horizontal distance covered is determined as follows:

$$S = Ah/\tan Y \quad \text{Eq A16}$$

While the aeroplane is accelerating in level flight, the horizontal distance covered is as follows:

$$S = f_w(V_{TAS2}^2 - V_{TAS1}^2)/2g(\bar{X}/W) - R \quad \text{Eq A17}$$

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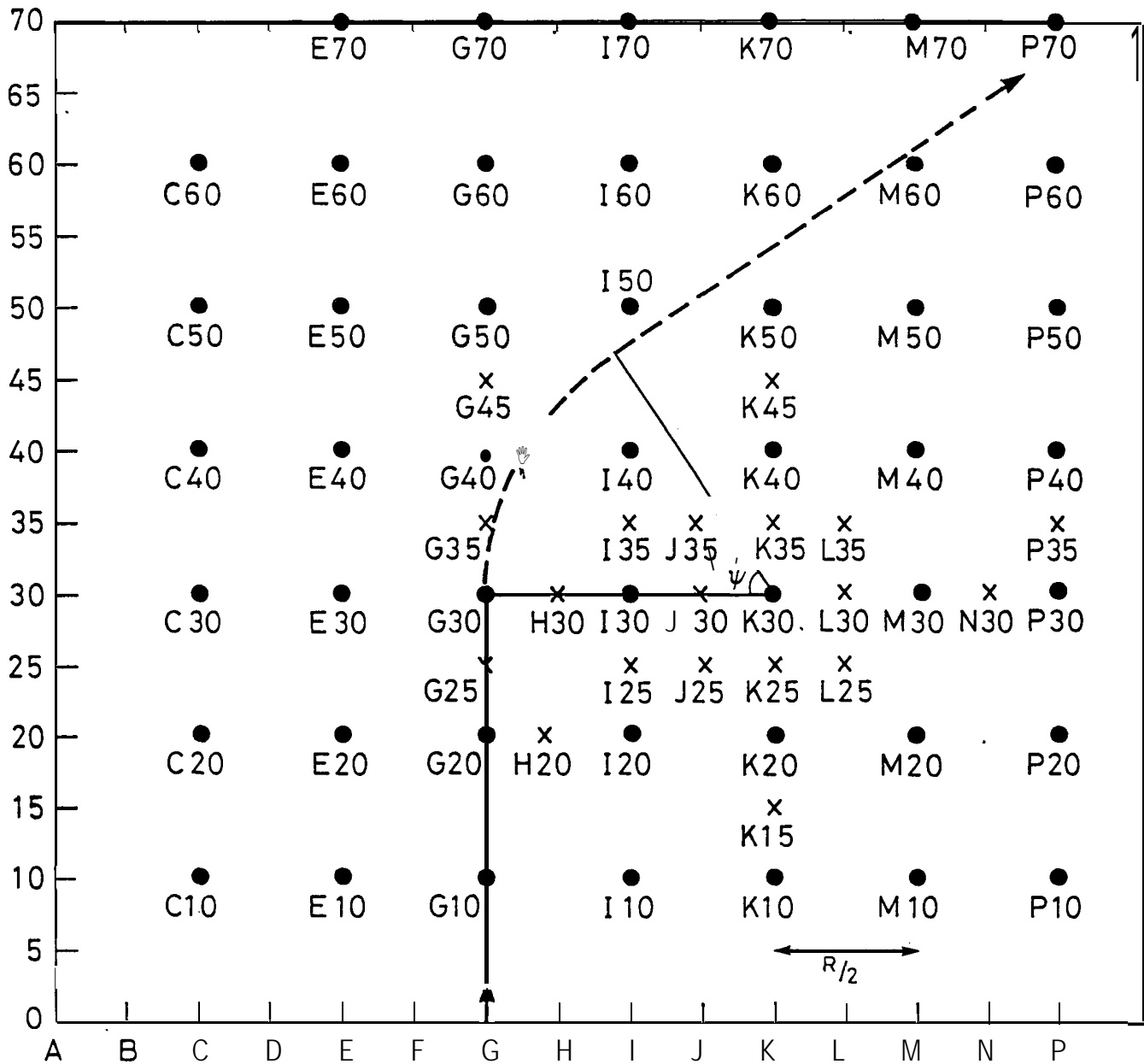
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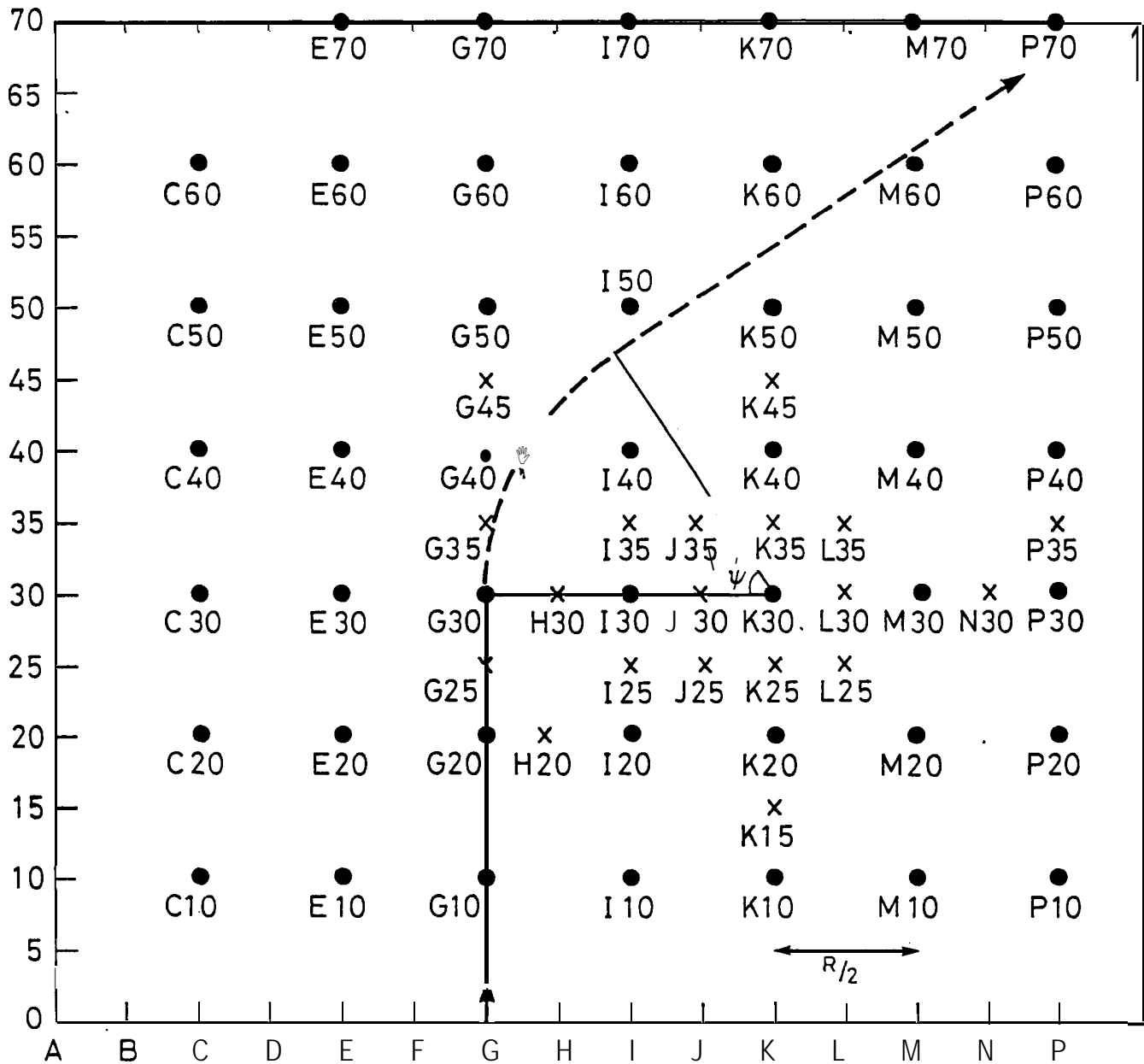
$$S = f_w(V_{TAS2}^2 - V_{TAS1}^2)/2g(\bar{X}/W) - R \quad \text{Eq A17}$$



Key:

- Main grid points
- × Intermediate grid points
- Start of turn at G30
- Centre of turn at K30
- Turn angle ψ

Figure B1. Secondary grid for geometry of an aeroplane turn



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Figure B1. Secondary grid for geometry of an aeroplane turn

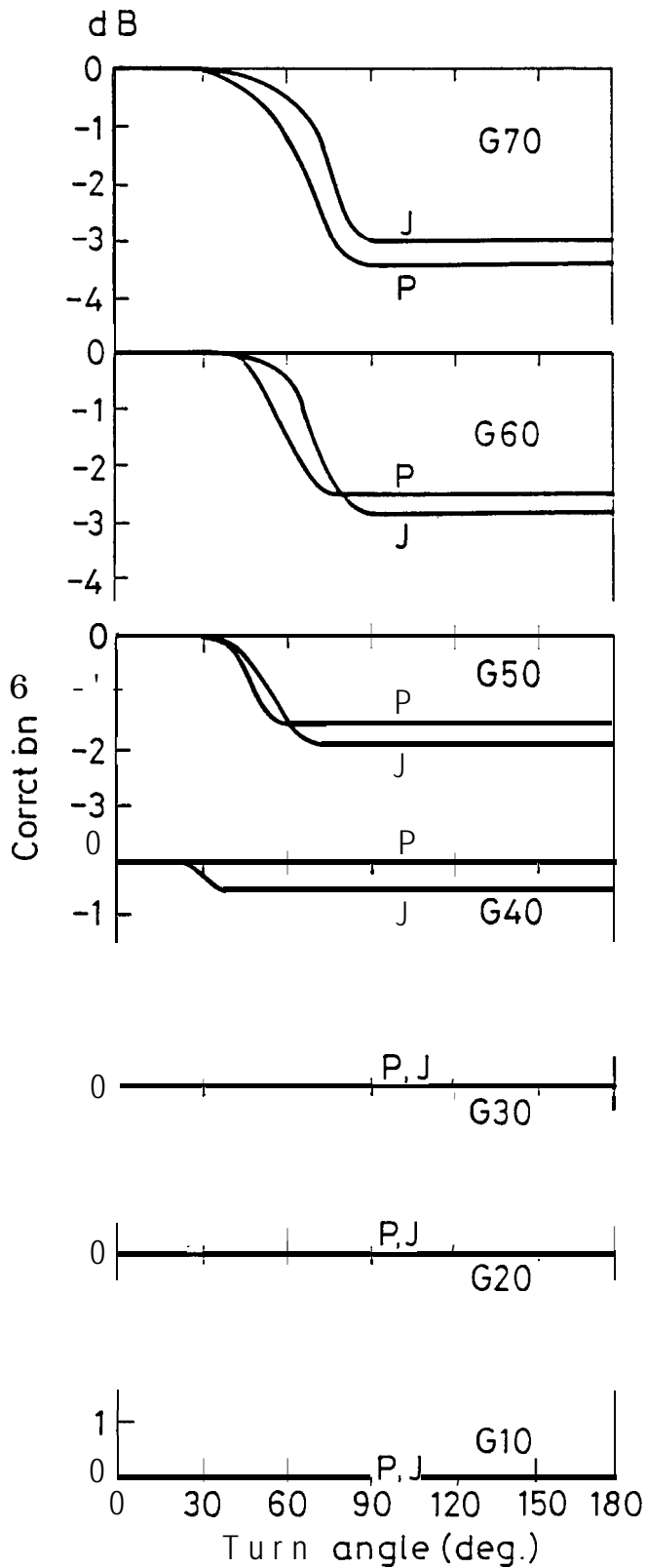


Figure B4. Corrections along grid-line G

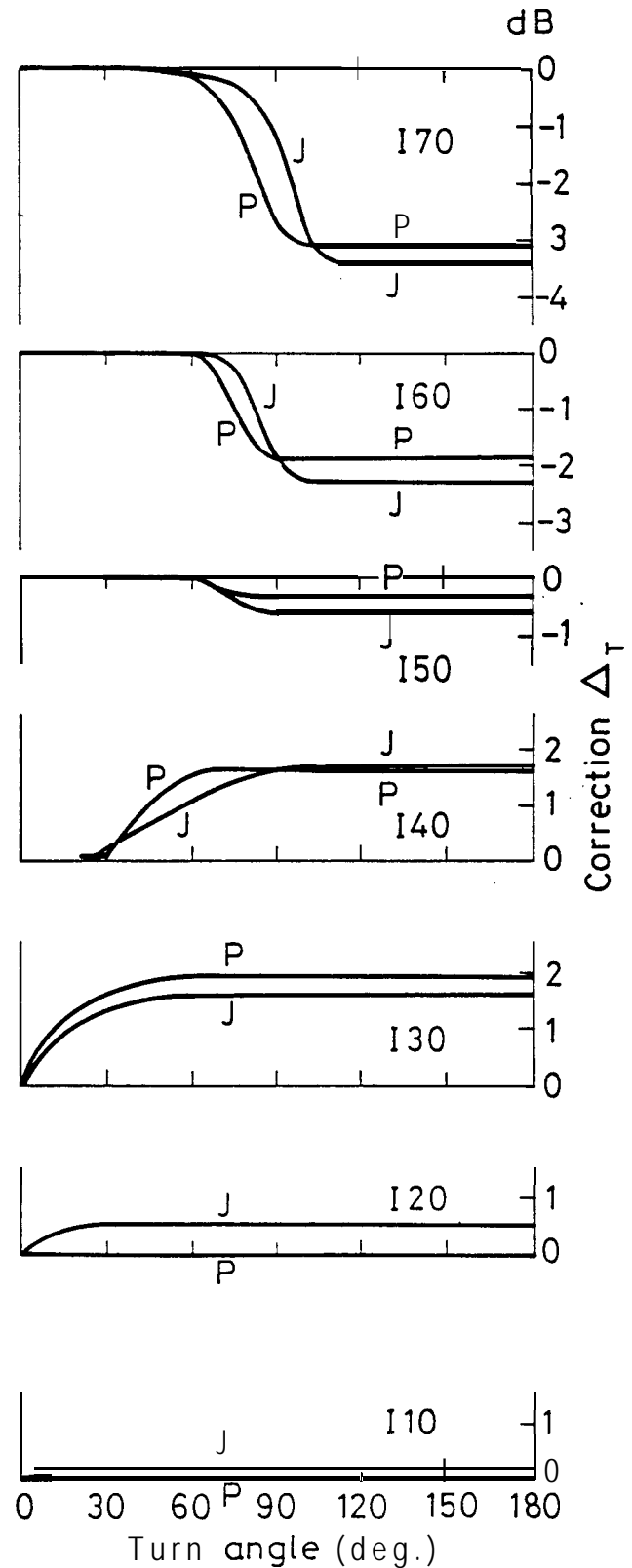


Figure B5. Corrections along grid-line I

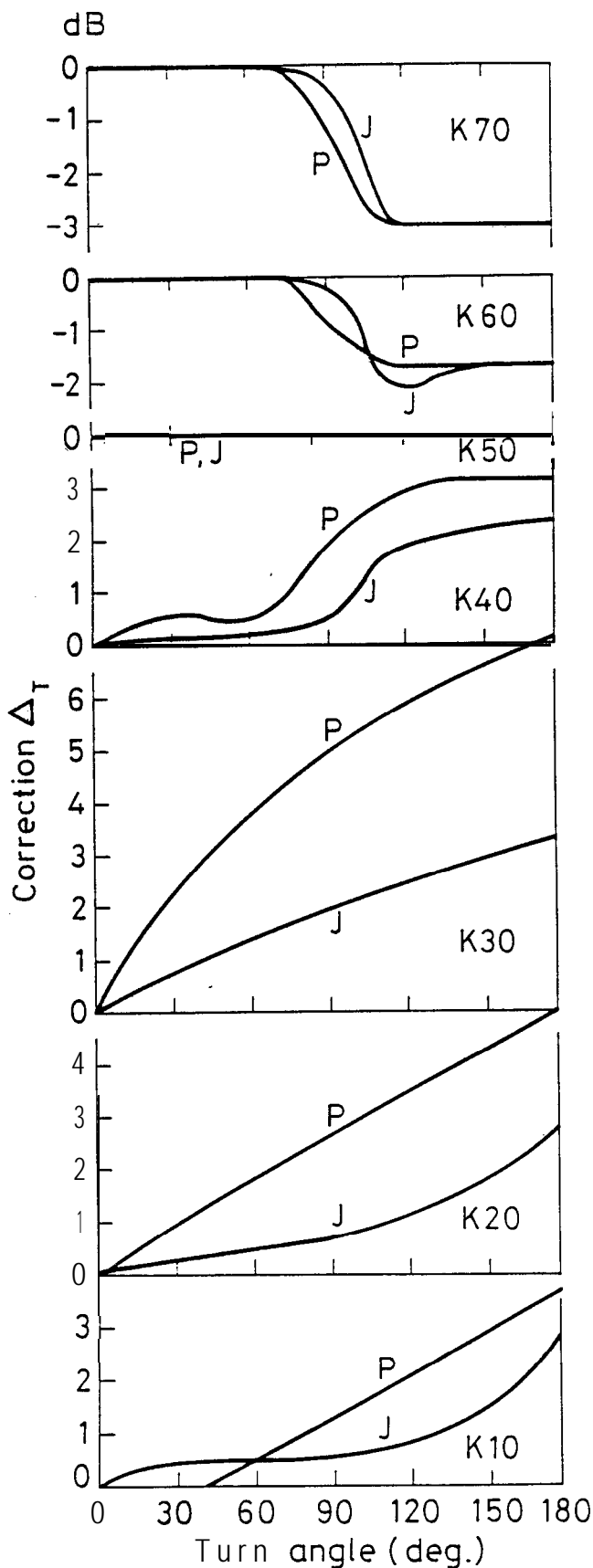


Figure B6. Corrections along
grid-line K

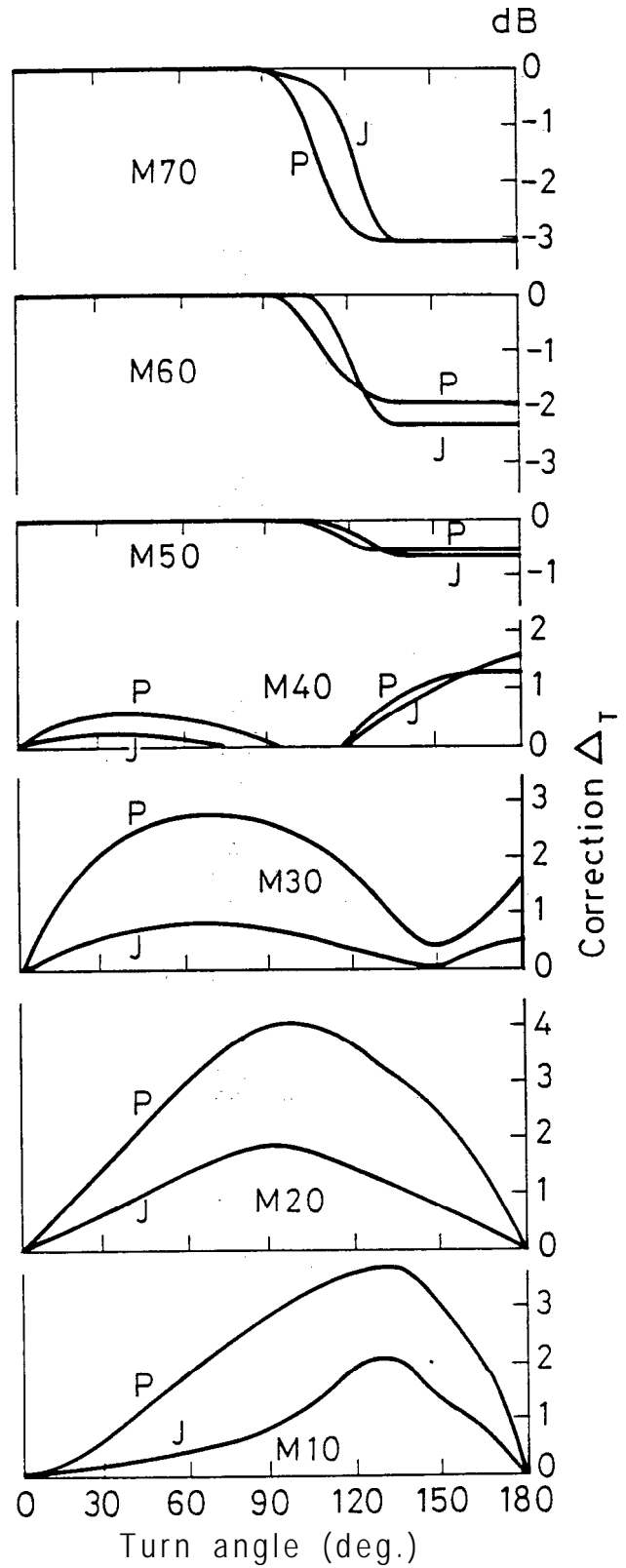


Figure B7. Corrections along
grid-line M

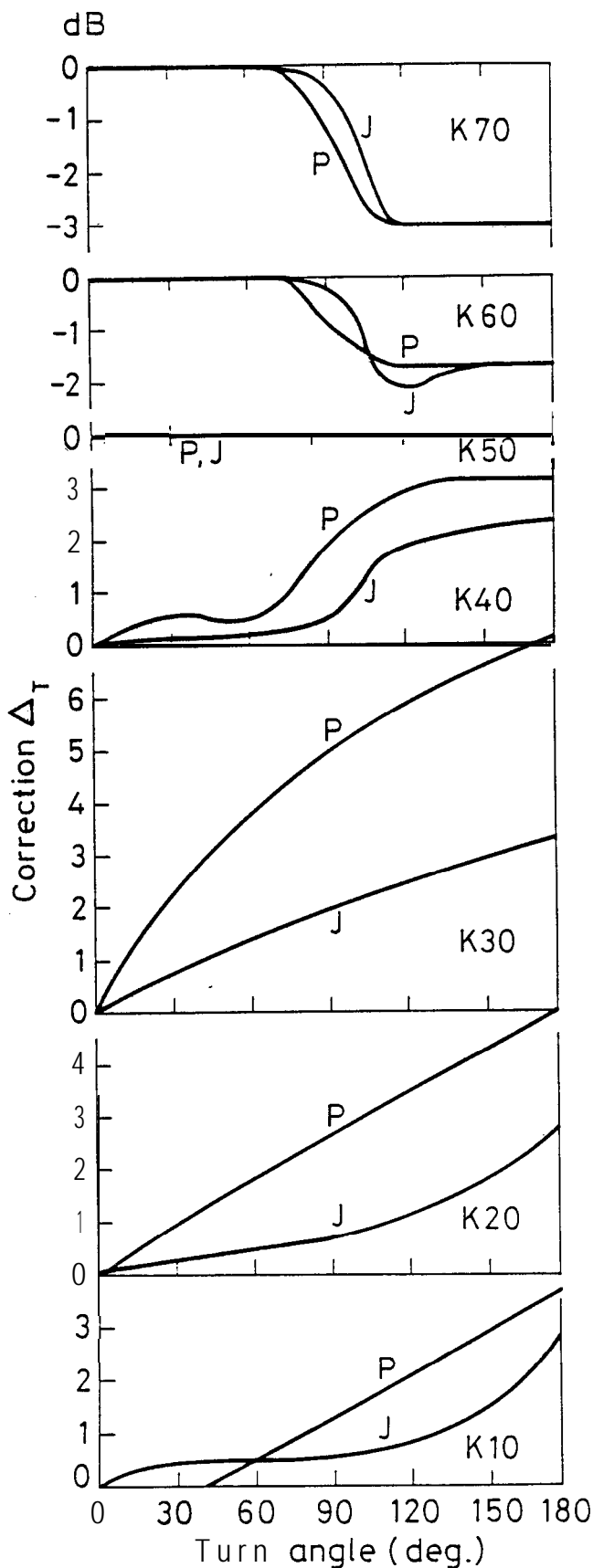


Figure B6. Corrections along
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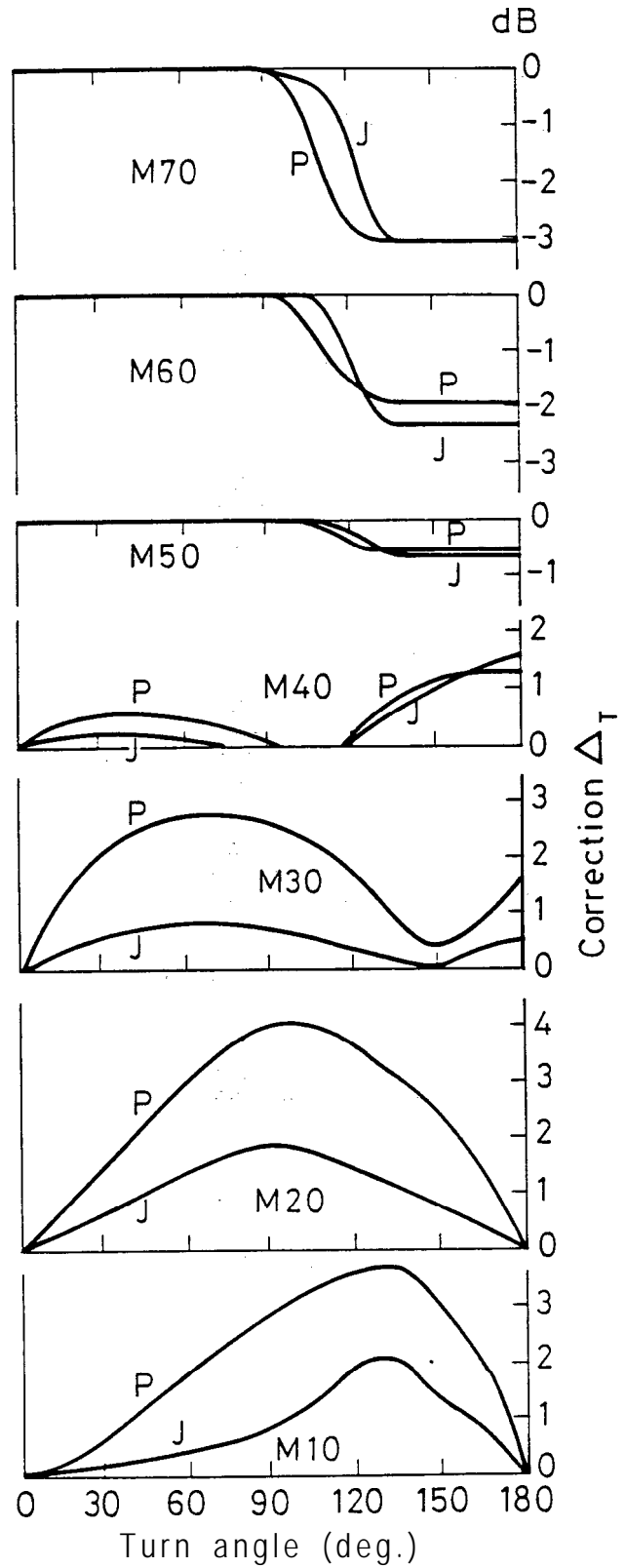


Figure B7. Corrections along
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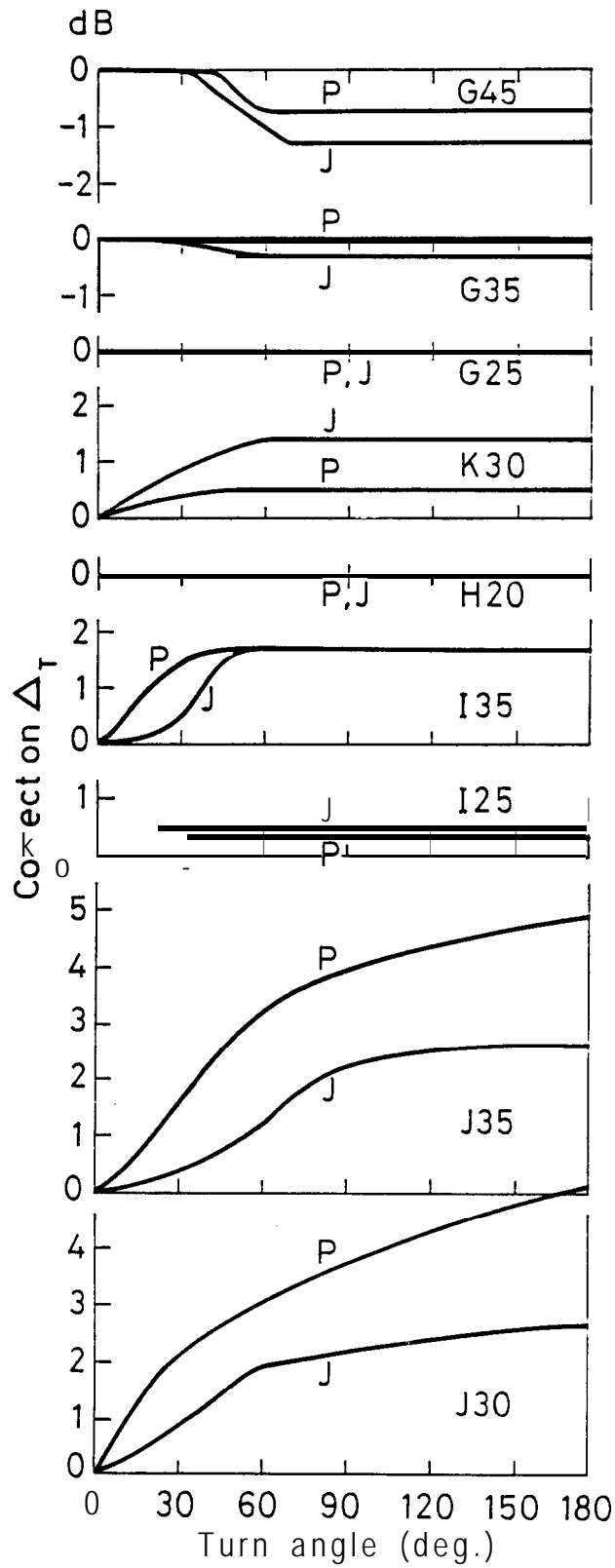


Figure B9. Corrections along
intermediate grid-lines

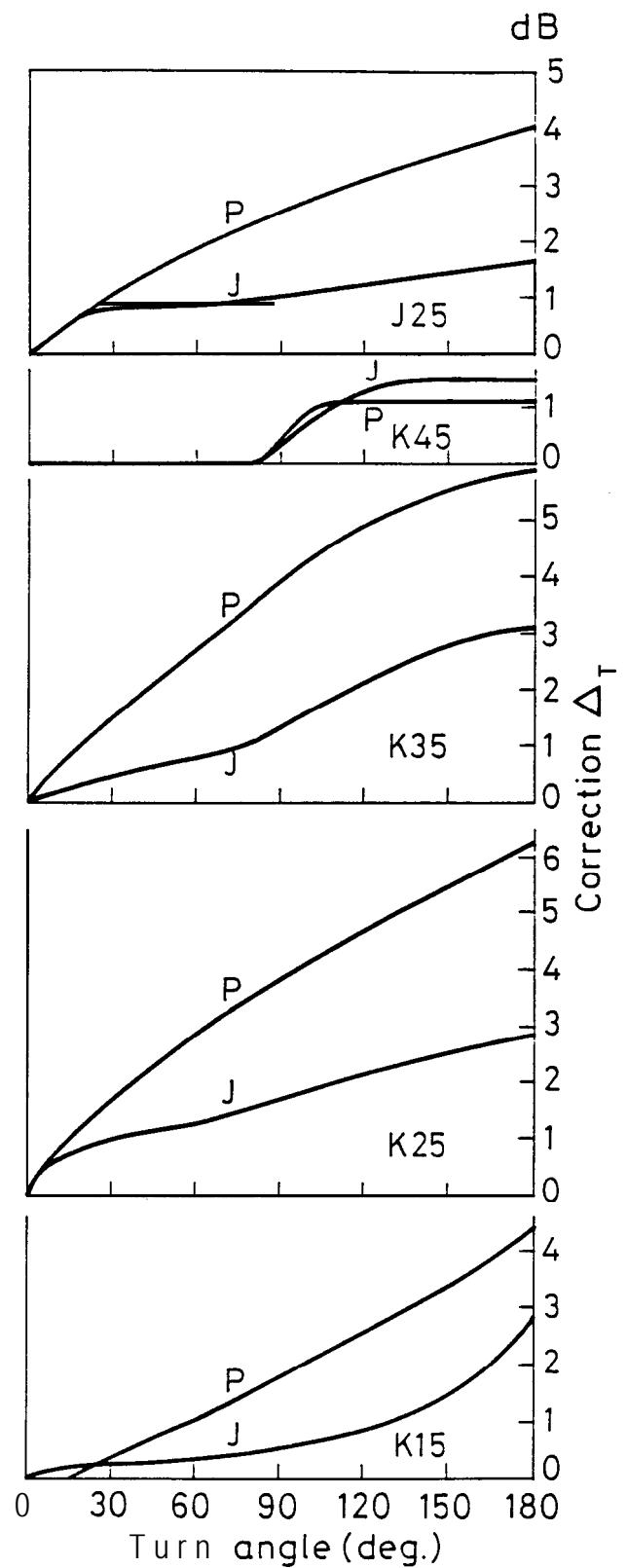


Figure B10. Corrections along
intermediate grid-lines

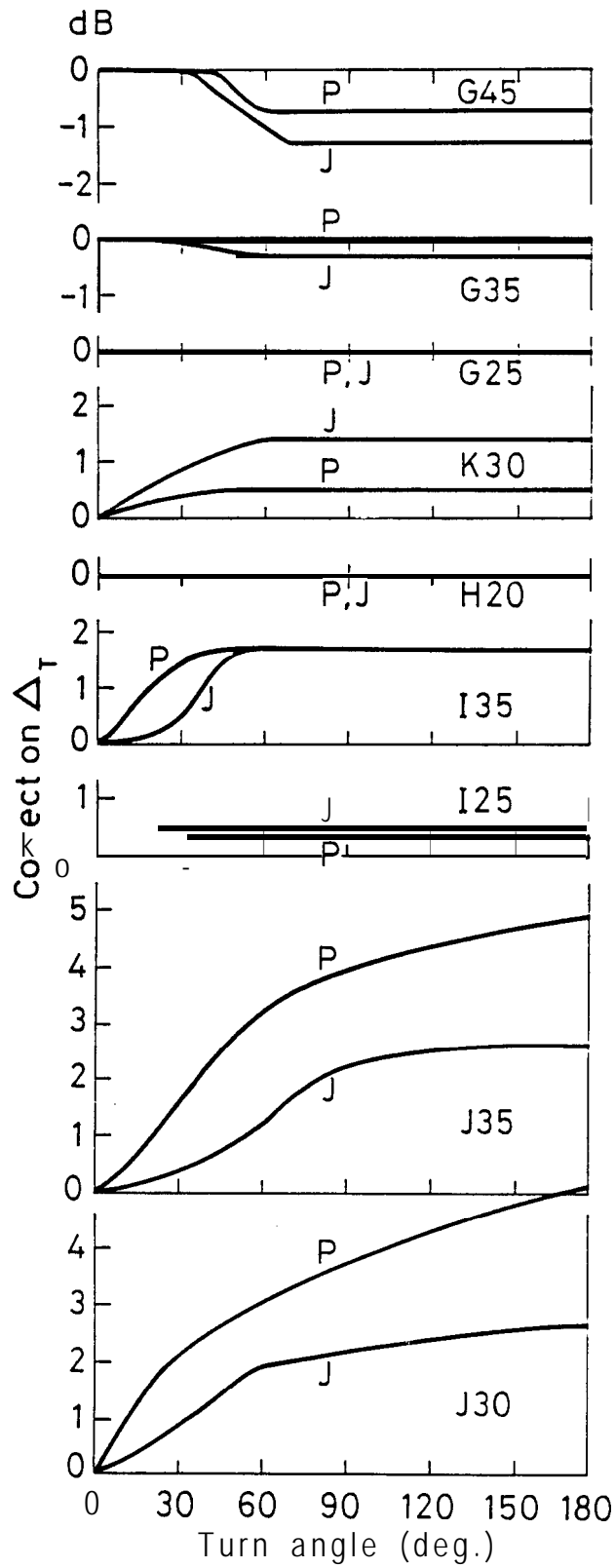


Figure B9. Corrections along
intermediate grid-lines

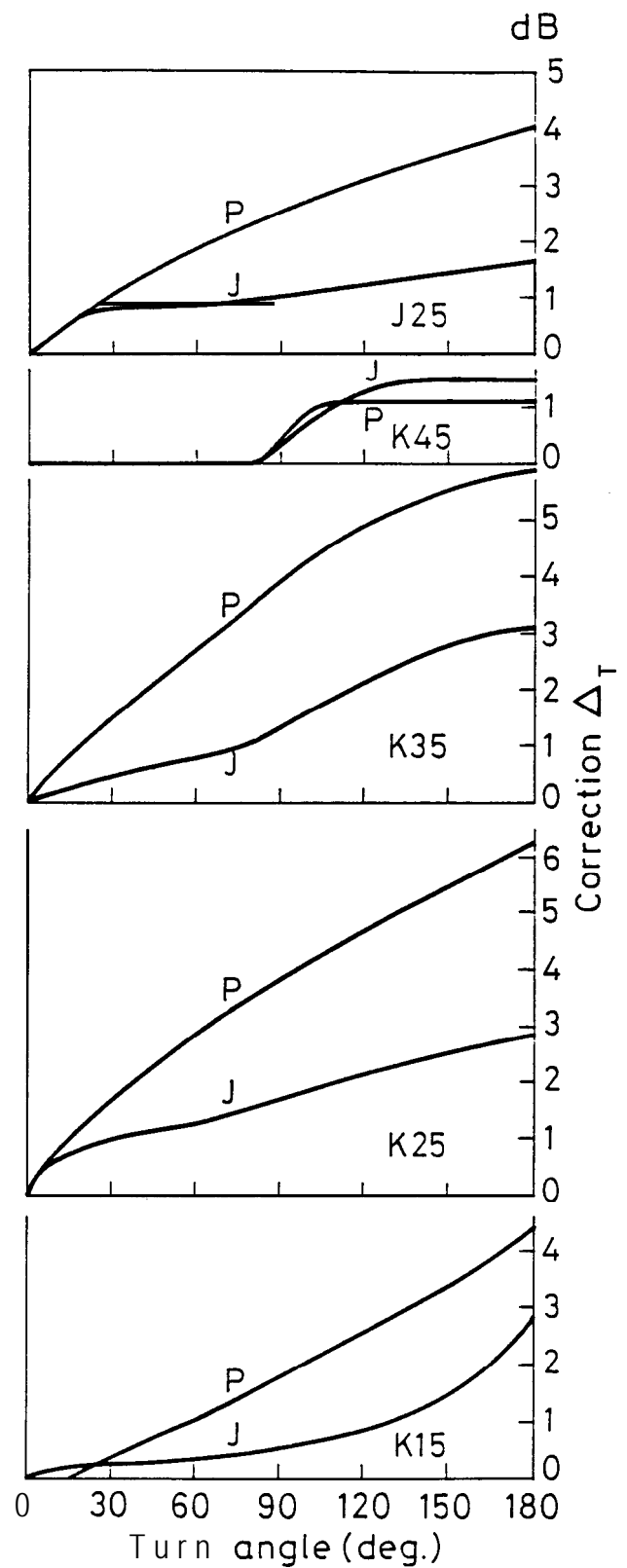


Figure B10. Corrections along
intermediate grid-lines

APPENDIX CNOISE INDICES IN USE IN ICAO MEMBER STATES

Individual member States have selected different noise indices for national use. The formulations of current indices are as follows:

C.1 Day-evening-night sound level, L_{DEN}

$$L_{DEN} = 10 \log (1/24) \{ 12 \times 10^{L_D/10} + 3 \times 10^{(L_E+5)/10} + 9 \times 10^{(L_N+10)/10} \}$$

where L_D , L_E and L_N are the equivalent continuous A-weighted sound pressure levels* over, respectively, the 12-hour daytime period 07 to 19 hours, the 3-hour evening period 19 to 22 hours and the 9-hour night period 22 to 07 hours.

C.2 Day-night average sound level, L_{dn}

$$L_{dn} = 10 \log (1/24) \{ 15 \times 10^{L_D/10} + 9 \times 10^{(L_N+10)/10} \}$$

where L_D and L_N are the equivalent continuous A-weighted sound pressure levels* over, respectively, the 15-hour daytime period 07 to 22 hours and the 9-hour night period 22 to 07 hours.

C.3 Equivalent sound level, L_{eq} , as defined in the Federal Republic of Germany:

$$L_{eq} = 13.3 \log \sum_i \{ g_i (t_i/T) 10^{L_i/13.3} \}$$

where L_i is the maximum A-weighted sound pressure level of an aeroplane fly-past i , t_i is the time interval within which the levels during the fly-past are

*The equivalent continuous A-weighted sound pressure level is usually given the symbol $L_{Aeq,T}$ (see ref 1 to main text). The symbols L_D , L_E and L_N used here are intended to indicate the time periods over which the levels are evaluated. This quantity is defined as follows:

$$L_{Aeq,T} = 10 \log \left\{ \left(1/(t_2-t_1) \right) \int_{t_1}^{t_2} (p_A^2(t)/p_0^2) dt \right\}$$

where $L_{Aeq,T}$ is the equivalent continuous A-weighted sound pressure level determined over a time interval T starting at t_1 and ending at t_2 , $p_A(t)$ is the instantaneous A-weighted sound pressure of the sound signal and p_0 is the reference sound pressure (20 μ Pa).

within 10 dB of the maximum, g_i is a weighting factor, different during the daytime (06 to 22 hours) from the night (22 to 06 hours) and T is the duration of evaluation (24 hours).

C.4 Equivalent continuous A-weighted sound pressure level, $L_{A,eq}$, as defined in Austria:

$$L_{A,eq} = 10 \log \left((1/t_{eq}) \int_0^{t_{eq}} 10^{L_A(t)/10} dt \right)$$

where $L_A(t)$ is the instantaneous A-weighted sound pressure level and t_{eq} is the evaluation period in seconds; $L_{A,eq}$ is evaluated separately over the 16-hour daytime period 06 to 22 hours and the 8-hour night period 22 to 06 hours.

C.5 Noise and number index, NNI

$$NNI = 10 \log \left\{ \sum_i (1/N) (10^{L_{PNI}/10}) \right\} + 15 \log N - 80$$

where L_{PNI} is the maximum perceived noise level of an aeroplane fly-past i and N is the total number occurring within the time period of evaluation (12-hour daytime in some States, 24 hours in others). In some States using this index, N is limited to the number of operations exceeding a certain value of L_{PNI} .

C.6 Noise exposure forecast, NEF

$$NEF = 10 \log \sum_i \sum_j 10^{NEF_{ij}/10}$$

where NEF_{ij} is a partial value for a specific class of aeroplanes, i , on a flight path, j , defined as follows:

$$NEF_{ij} = L_{EPNij} + 10 \log (n_{Dij} + 16.67n_{Nij}) - 88$$

where, in turn, L_{EPNij} is the Effective Perceived Noise Level at the observation point considered, for the aeroplanes and flight path concerned, n_{Dij} is the number of operations during the 15-hour day (07 to 22 hours) and n_{Nij} is the number during the 9-hour night (22 to 07 hours).

C.7 Noise exposure index, B

$$B = 20 \log \sum_i (n_i 10^{L_{pi}/15}) - 157$$

where L_p is the maximum A-weighted sound pressure level of an aeroplane fly-past and n is a weighting factor which varies with different times during the day and night.

C.8 Psophic index, Ip

$$I_p = \{10 \log ((\sum_i 10^{L_{Di}/10}) + (\sum_j 10^{(L_{Nj}+10)/10}))\} - 32$$

where L_{Di} is the maximum perceived noise level of an aeroplane fly-past i during the 16-hour day (06 to 22 hours) and L_{Nj} is that of aeroplane fly-past j during the 8-hour night (22 to 06 hours).

C.9 Weighted equivalent continuous perceived noise level, WECPNL, as defined in Japan:

$$WECPNL = \{10 \log ((1/n) \sum_i 10^{L_i/10})\} + 10 \log N - 27$$

where L_i is the maximum A-weighted sound pressure level of an aeroplane fly-past i , n is the number of operations within a 24-hour period, and N is based upon the number with weightings for the numbers during the daytime (07 to 19 hours), evening (19 to 22 hours) and night (22 to 07 hours).

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Agenda Item 4: Aircraft Engine Emissions

Review of the report of the focal point with a view to developing future course of action.

4.1 Introduction

4.1.1 The meeting noted that ICAO provisions relating to aircraft engine emissions were at present contained in Volume II of Annex 16. These provisions had been developed by the Committee on Aircraft Engine Emissions at its second meeting (CAEE/2) held in May 1980. At CAEE/2 a number of items of future work had been identified and focal points had been nominated to pursue these work items. Subsequent to CAEE/2, the Committee on Aircraft Engine Emissions was disbanded, but its remaining work had been included in the tasks of the Committee on Aviation Environmental Protection. The focal points had consequently continued their work.

4.1.2 The general topics which had been assigned to the focal points were as follows:

- a) air quality aspects;
- b) technical aspects;
- c) cost effectiveness;
- d) vapour displacement from fuel tanks.

The results of the work of the focal points were discussed by the meeting and are reported on below together with other matters that have arisen since CAEE/2, together with discussions on future work in the engine emissions field.

4.2 Air quality aspects

4.2.1 The focal point on air quality aspects had been asked to pursue the following items:

- a> gather information on air pollution modelling techniques in and around airports;
- b) collect and summarize the results of air quality monitoring studies at airports;
- c) compile information concerning the need to control emissions from turboprop, turboshaft and APU engines;
- d) monitor ongoing studies of high altitude pollution, including modelling of the atmosphere and data collection programmes;

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- d) monitor ongoing studies of high altitude pollution, including modelling of the atmosphere and data collection programmes;

- a> unresolved matters and developments in emission instrumentation and measurement technology;
- b) the quantification of smoke visibility measurements;
- c) the prediction of HC and CO cruise emissions from ground test bed measurements; and
- d) low emissions combustor technology developments.

4.3.2 Line temperatures

Comments had been received by the focal point on measurement techniques, in particular on the subject of the temperature of the sampling lines. The proposals made were considered to be reasonable and minor amendments to Appendices 2 and 3 of Annex 16, Volume II were therefore proposed and agreed by the meeting. The proposed changes are shown in the Attachment to the report on this Agenda Item.

4.3.3 Characterization of exhaust hydrocarbons

Further comment was also received on this topic and proposals made for a fundamental change in procedures. It was pointed out that these had already been discussed and rejected at CAEE/2 and it was therefore agreed not to pursue them further now.

4.3.4 Fuel specification

4.3.4.1 Experience in using the ICAO provisions had shown that great difficulty existed in obtaining fuel meeting the specification in Appendix 4. This had meant that special dispensations had had to be granted in almost all cases of emissions certification tests to allow the use of fuel outside the Appendix 4 specifications. A number of members had therefore made proposals for revised fuel specifications which more closely met the fuel which was readily available around the world.

4.3.4.2 Concern was expressed that a relaxation of the fuel specification limits might in effect reduce the stringency of the requirements. The meeting was assured that this was not the case and that the environmental impact of the proposed changes would be negligible. In one case at least (increasing the upper limit on aromatics), use of fuel at the upper limit of the new specification could make particularly the smoke provisions more difficult to meet.

4.3.4.3 The various proposals for amending the specifications were examined in detail. It was pointed out that there was a trend towards lighter fuels in many States and this meant a lowering of the kinematic viscosity limit, a lowering of the boiling points and an increase in the maximum hydrogen content - all of which characteristics were interrelated. Changes were also agreed to the upper limits on naphthalenes and aromatics. A proposal to lower the lower limit on aromatics content to align with the availability of fuel in one State was not

agreed since it was felt that this could have had the effect of reducing the stringency of the requirements. The proposed changes which were agreed are shown in the Attachment to the report on this Agenda Item.

4.3.5 Corrections for test atmospheric conditions

The meeting examined a proposal by one member concerning the methods of correcting test results to the reference atmospheric conditions. It was suggested that the method given at present in Annex 16, Volume II did not work very satisfactorily and an alternative method which had given better results in limited tests was described. It was agreed that the proposed new method should undergo more widespread testing before it could be considered for inclusion in Annex 16.

4.3.6 Leakage flow rates

One member pointed out that the leakage flow rate permitted by Annex 16, Volume II during tests for smoke was different to that permitted during gaseous emissions tests. There was no technical reason for this, which appeared to be the result of an oversight during the development of the provisions at CAEE/2. In view of the fact that smoke and gaseous emissions tests were often conducted simultaneously with the same test equipment, it was considered to be desirable to align the leakage rates. The majority of members felt however that they had had insufficient time to study this proposal and it was therefore agreed that it should be assigned to future work.

4.4 Cost effectiveness aspects

It was reported that the focal point had received no information on this topic and it was questioned whether it should be retained for future consideration. It was agreed that this was an implicit factor in all the Committee's considerations and need not therefore be retained for special study.

4.5 Vapour displacement from fuel tanks

4.5.1 The focal point for this topic had been asked to collect information on the following points:

- a) investigate the extent of the contribution to air pollution around airports by the fuel vapours displaced into the atmosphere when aircraft refuelling is carried out;
- b) investigate this situation for different aircraft types, and for any different types of refuelling systems in use at major airports in the various States of the Committee; and
- c) if necessary, determine whether it is technically feasible and economically reasonable to develop possible alternative systems of refuelling to reduce the emanation of the fuel vapours to the atmosphere .

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- c) if necessary, determine whether it is technically feasible and economically reasonable to develop possible alternative systems of refuelling to reduce the emanation of the fuel vapours to the atmosphere .

- b) continued collection and summary of aerodrome air quality monitoring studies;
- c) continued review of the need to control emissions from turboprop, turboshaft and APU engines;
- d) an examination of the applicability of the ICAO Standards to propfan engines;
- e) continued review of the test fuel specification;
- f) a review of the adequacy of the NO_x emission standards;
- g) a review of the possible refinement of individual provisions of Annex 16, Volume II, in particular:
 - 1) the **representativeness** of the gas sample;
 - 2) the methodology for correcting gaseous and smoke emission measurements to the reference atmospheric conditions;
 - 3) the establishment of smoke requirements for engines with different types of jet nozzle;
 - 4) a review of the precision of the fuel venting requirements; and
 - 5) a review of the sampling system leakage flow requirements.

4.8 Recommendations

In view of the foregoing discussions, the meeting developed the following recommendation:

RSPP	<p><u>RECOMMENDATION 4/1 - AMENDMENT OF ANNEX 16, VOLUME II</u></p> <p>That Annex 16, Volume II, be amended as indicated in the Attachment to this part of the report.</p>
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- b) continued collection and summary of aerodrome air quality monitoring studies;
- c) continued review of the need to control emissions from turboprop, turboshaft and APU engines;
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- e) continued review of the test fuel specification;
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Agenda Item 5: Future activities of the Committee5.1 Introduction

Under this agenda item, the Committee considered:

- a) a comprehensive work programme to be accomplished during the next phase of the Committee's work;
- b) assignment of **tasks to** working groups; and
- c) consideration of the need for a second meeting, including, as necessary, proposals for a tentative agenda.

5.2 Future work programme

5.2.1 During discussions on the various agenda items in which, due to **lack** of available resources in national administrations, the need to confine future work to truly essential **issues was** recognized. The Committee nevertheless identified several problems requiring further study during the Committee's future work in order to achieve the objectives of the Committee's terms of reference. A detailed description of these tasks is contained in paragraphs 1.3, 2.6, 3.3 and 4.7 of this report.

5.2.2 It was suggested that in the development of noise certification provisions by the Committee due consideration was not being given at **present** to the protection of the environment and the level of stringency was being determined mostly on the basis of technological developments and economic reasonableness. It was pointed out that at an increasing number of **noise-sensitive** airports, noise limits exist which restrict the total acceptable noise exposure. At these airports the expected increase in air traffic movements can only be accepted if the average noise emission per aircraft movement will decrease. It was further suggested that in determining effectiveness and reliability of certification schemes the Committee should assess the impact on the environment and also take into consideration the benefits that could be achieved through operational restrictions. It was further proposed that the work programme includes a specific item requiring an assessment of environmental problems associated with continued operation of Chapter 2 **aeroplanes at noise-sensitive** airports.

5.2.2.1 The above proposal was opposed by several members it being stressed that operational aspects were outside the terms of reference of the Committee. The Committee was informed that related studies for selected airports had been undertaken in Europe. A study had also been initiated in the United States to investigate the relative advantages and disadvantages at selected airports of gradual replacement of Chapter 2 **aeroplanes with Chapter 3 aeroplanes**. Final results of this study will be available towards the end of 1986. The Committee

however cautioned that such studies involved considerable effort and costs and it would result in a tremendous workload for the Committee if it were to embark on such a study, which would have to take into account relevant aspects on a global basis. The result of earlier work of this type had been reported to CAN/7. It was therefore felt that such studies should be taken by individual States on the basis of their own needs and policies with regard to the protection of the environment.

5.2.2.2 After some discussion, the Committee decided not to include this task in its work programme. It, however, requested the members nominated by States which had undertaken such studies to provide the results to ICAO for use by other interested bodies and to all members/observers of the Committee to facilitate their contributions towards progressing the Committee's work on the further development of the noise certification schemes, and in particular to increasing the level of stringency of these schemes.

5.2.3 It was proposed that the development of appropriate noise level standards for future supersonic **aeroplanes** be included in the work programme. It was explained that since noise was one of the critical factors affecting the general acceptance of supersonic **aeroplanes** and would also be a major constraint on any new designs, it would be desirable to develop suitable standards before the designs of such **aeroplanes** are finalized by manufacturers.

5.2.3.1 Some members were of the opinion that the Committee should wait until more detailed information was available with regard to the technology to be used in the development of new designs before noise certification standards are formulated. However, the majority of the members were of the opinion that the Committee should undertake this task now and furthermore when developing the requirements it should ensure that future supersonic transport **aeroplanes** are subjected to the same level of stringency with regard to maximum noise levels as that specified for subsonic jet **aeroplanes** and heavy propeller-driven **aeroplanes**. After some discussion, the Committee agreed to recommend inclusion of this task in its work programme.

5.2.4 The Committee was informed that in several States stringent rules were being established to protect workers from noise. Also aircraft manufacturers were increasingly being requested by operators to reduce the noise levels experienced in the cockpit. It was suggested that to introduce international homogeneity, it would be desirable that requirements for control of noise in the cockpit be developed by ICAO and a suitable item be included in the work programme of the Committee.

5.2.4.1 A majority of the members were, however, of the opinion that this subject was not appropriate for this Committee and it was concerned more with medical aspects than technical aspects. The member nominated by the United States informed the Committee that investigation undertaken so far had not indicated any evidence of hearing damage to crew members. Excessive cabin noise could, however, affect crew communication in the cockpit but this would be a problem related to safety rather than to protection of the environment. The

however cautioned that such studies involved considerable effort and costs and it would result in a tremendous workload for the Committee if it were to embark on such a study, which would have to take into account relevant aspects on a global basis. The result of earlier work of this type had been reported to CAN/7. It was therefore felt that such studies should be taken by individual States on the basis of their own needs and policies with regard to the protection of the environment.

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5.3.4 Taking into consideration the work programme developed by the Committee, it was agreed that three working groups should undertake the following tasks:

Working Group I - tasks related to noise certification of jet aeroplanes, including supersonic transport aeroplanes, and heavy propeller-driven aeroplanes;

Working Group II - tasks related to noise certification of light propeller-driven aeroplanes, including ultra-light aircraft, and helicopters;

Working Group III - tasks related to aircraft engine emissions.

5.3.5 The Committee agreed to the following composition of the three working groups:

a) Working Group I

Members/observers or their advisers nominated by:

Brazil; Canada; France (Rapporteur Mr. P.L. Arslanian); Japan; Netherlands, Kingdom of the; Sweden; Union of Soviet Socialist Republics; United Kingdom; United States; AACC; IATA; and ICCAIA.

b) Working Group II

Members/observers or their advisers nominated by:

Australia; Brazil; Canada; France; Germany, Federal Republic of; Italy; Japan; Netherlands, Kingdom of the; Switzerland; Union of Soviet Socialist Republics; United Kingdom; United States (Rapporteur Mr. R. Tedrick); AACC and ICCAIA.

c) Working Group III

Members/observers or their advisers nominated by:

Canada; France; Germany, Federal Republic of; Japan; Union of Soviet Socialist Republics; United Kingdom; United States (Rapporteur Mr. N. Krull); AACC and ICCAIA.

It was further agreed that Mr. P. Kearsey will be the Rapporteur of the Technical Issues Subgroup to assist Working Groups I and II.

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ATTACHMENT A TO THE REPORT ON AGENDA ITEM 5REVISED WORK PROGRAMME OF THE CAEP1. Noise certification of helicopters

Further development of noise certification Standards and procedures including review of technological development, certification costs, examination of practicability and economic reasonableness of increasing stringency for different types of helicopters including their derived versions and further development of test procedures including equivalent procedures.

2. Noise certification of propeller-driven aeroplanes

a) Further development of noise certification standards and procedures including review of technological development, certification costs, examination of practicability and economic reasonableness of increasing stringency for different types of propeller-driven aeroplanes and further development of test procedures.

b) Development of noise certification requirements for ultra-light aircraft.

3. Noise certification of subsonic jet aeroplanes

Further development of noise certification standards and procedures including review of technological development, certification costs, examination of practicability and economic reasonableness of increasing stringency for different types of subsonic jet aeroplanes and further development of test procedures including equivalent procedures.

4. Noise certification of supersonic transport aeroplanes

Development of noise certification standards and procedures for supersonic transport aeroplanes taking into account technological development, practicability and economic reasonableness.

5. Aircraft engine emissions

a) Review of modelling techniques and monitoring of air quality studies with a view to determining the need for further control of emissions from aircraft in the vicinity of aerodromes including the extension of the applicability of Annex 16, Volume II, to other types of engines.

b) Review of the adequacy of the current emission standards and development of proposals, as necessary, for possible refinement and increased stringency, of the individual provisions of Annex 16, Volume II.

c) Monitoring of international and national programmes of research into the effects of emissions for aircraft on atmosphere above 900 metres.

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c) Monitoring of international and national programmes of research into the effects of emissions for aircraft on atmosphere above 900 metres.

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ATTACHMENT B TO THE REPORT ON AGENDA ITEM 5TERMS OF REFERENCE OF WORKING GROUP IJet and Heavy. Propeller Aeroplanes

The Group is required:

1. To consider the needs for increasing the stringency of the relevant Chapters of Annex 16, taking into account the way in which air traffic **is likely** to develop.
2. To review and report to the Committee on advances in acoustic technology in relation to Item 1 and their possible impact on noise certification standards.
3. To investigate and report to the Committee on means of improving noise test specifications and the testing, reporting and analysis procedures.
4. To investigate the need to measure noise levels at lesser distances than those currently specified in Chapters 2 and 3 and the procedures for correcting these to the reference positions in relation to Items 1 and 2.
5. To consider additional material and amendments for the proposed ICAO Environmental Technical Manual and the proposed document for computing noise contours around airports and to establish procedures for the incorporation of such changes.
6. To consider the possibility of using noise footprints as a basis for noise certification purposes.
7. To consider the development of standards to be introduced for future supersonic transport aeroplanes.

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ATTACHMENT B TO THE REPORT ON AGENDA ITEM 5TERMS OF REFERENCE OF WORKING GROUP IJet and Heavy. Propeller Aeroplanes

The Group is required:

1. To consider the needs for increasing the stringency of the relevant Chapters of Annex 16, taking into account the way in which air traffic **is likely** to develop.
2. To review and report to the Committee on advances in acoustic technology in relation to Item 1 and their possible impact on noise certification standards.
3. To investigate and report to the Committee on means of improving noise test specifications and the testing, reporting and analysis procedures.
4. To investigate the need to measure noise levels at lesser distances than those currently specified in Chapters 2 and 3 and the procedures for correcting these to the reference positions in relation to Items 1 and 2.
5. To consider additional material and amendments for the proposed ICAO Environmental Technical Manual and the proposed document for computing noise contours around airports and to establish procedures for the incorporation of such changes.
6. To consider the possibility of using noise footprints as a basis for noise certification purposes.
7. To consider the development of standards to be introduced for future supersonic transport aeroplanes.

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ATTACHMENT C TO THE REPORT ON AGENDA ITEM 5TERMS OF REFERENCE OF WORKING GROUP IILight Propeller-Driven **Aeroplanes** and Helicopters

The group will study and report to the Committee on the following:

1. The further review of the Light Propeller-Driven **Aeroplane** and Helicopter Noise Certification Standards with respect to the environmental need for increased stringency consistent with technical feasibility and economic reasonableness.
2. The prospects for developing operational procedures for meaningful noise abatement in liaison with ICAO operational panels for both aircraft types.
3. The possibility of improving test specifications and adjustment and analysis methods through analytical and empirical efforts with a view of specifically clarifying the contribution of source noise components and relevant flight and operational parameters in order to reduce certification cost and complexity.
4. The development of draft noise certification requirements for ultra-light aircraft.
5. The development of guidance material for possible inclusion in future issues of the ICAO Environmental Technical Manual in particular test window constraints, limitations on emission angles for lateral measurements and meteorological requirements.
6. The continued evaluation of issues leading to and arising from the Helicopter Noise Measurement Repeatability Program (e.g. studies of the take-off procedure to assure consistency with airworthiness requirements and of speed control on approach including the need for continuous tracking for all tests).
7. The facility of implementation of both Chapter 8 and Chapter X as related to technology advances related to both aircraft types.

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ATTACHMENT C TO THE REPORT ON AGENDA ITEM 5TERMS OF REFERENCE OF WORKING GROUP IILight Propeller-Driven **Aeroplanes** and Helicopters

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7. The facility of implementation of both Chapter 8 and Chapter X as related to technology advances related to both aircraft types.

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ATTACHMENT C TO THE REPORT ON AGENDA ITEM 5TERMS OF REFERENCE OF WORKING GROUP IILight Propeller-Driven **Aeroplanes** and Helicopters

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1. The further review of the Light Propeller-Driven **Aeroplane** and Helicopter Noise Certification Standards with respect to the environmental need for increased stringency consistent with technical feasibility and economic reasonableness.
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7. The facility of implementation of both Chapter 8 and Chapter X as related to technology advances related to both aircraft types.

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ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue or the Meteorological Tables for International Air Navigation.

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